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ABSTRACT

This paper is an examination of the relationship of measures of academic achievement and other personal characteristics to job productivity of college graduates in a particular situation. Data used pertain to persons working in a large corporation employing both technical and non-technical employees. Data on background characteristics, salary and position in the corporation in 1968 were obtained from a survey of 1,300 persons hired by the corporation between 1946 and 1965. College quality and grades are shown to be consistently related to the rate of salary increase and the rate of promotion, although they seem not to be related to initial salary. Leadership ability and initial job experiences allowing expression of one's own ideas are also shown to be positively associated with job performance, while a strong desire for job security is negatively associated with the rate of salary increase. (Author/MJM)

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University of California, Berkeley
Academic Assistant to the President

OFFICE ADDRESS

2288 Fulton Street
Berkeley, California 94720
(415) 642-5490

ACADEMIC ACHIEVEMENT AND JOB PERFORMANCE:
EARNINGS AND PROMOTIONS

David A. Wise

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PREFACE

This is one of a continuing series of reports of the Ford Foundation sponsored Research Program in University Administration at the University of California, Berkeley. The guiding purpose of this Program is to undertake quantitative research which will assist university administrators and other individuals seriously concerned with the management of university systems both to understand the basic functions of their complex systems and to utilize effectively the tools of modern management in the allocation of educational resources.

Numerous studies of returns to investment in human capital have demonstrated that earnings are positively correlated with educational level. Persons are selected and certified in the higher educational system largely on the basis of measures of academic aptitude or performance. But the relationship between these measures and job productivity is not generally known. This paper is an examination of the relationships of measures of academic achievement and other personal characteristics to job productivity of college graduates in a particular situation.

College quality and grades are shown to be consistently related to the rate of salary increase and the rate of promotion, although they seem not to be related to initial salary. Leadership ability and initial job experiences allowing expression of one's own ideas are also shown to be positively associated with job performance; while a strong desire for job security is negatively associated with the rate of salary increase.

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This paper is an examination of the relationship of measures of academic achievement and other personal characteristics to job productivity of college graduates working in a large corporation.

Numerous studies of returns to investment in human capital have demonstrated quite clearly that the more educated earn more than those with less education.[1] These studies, however, do not tell us why this is so. As one recent observer has put it:[2]

> Do schools contribute to economic opportunity? It can certainly be demonstrated that the longer one stays in school, up to 20 years at least, the higher one's income is likely to be. But whether this is due to capacities actually developed through instruction, or the effect on character and personality of decades of submission to school routines, or merely the consequence of a complex, interlocking series of credentials which restrict opportunities to those who have satisfied the authorities at an earlier stage is not clear. All these processes are involved and are interrelated. But I have listed them, I think, in ascending order of their influence, though apologists for the educational system would prefer, I believe, that the order be reversed.

Entry into higher level jobs is often restricted to college graduates and in many cases graduate or professional degrees are required. Persons are selected and certified in the higher educational system largely on the basis of measures of academic aptitude or performance. But the relationship between these measures and job performance (or productivity) is not generally known. The assumption of economic efficiency, however, would imply the existence of a causal relationship and equity would require it. A requisite of fairness, the intended meaning of equity, would presumably be that persons with the same productive potential in an occupational field have the same opportunity to enter it.

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[1] See for example: Becker [1964], Hanoch [1967], Thurow [1967].

[2] Friedenberg [1971].

1. Background and Outline

The Initial Question.

This investigation was motivated by a desire to study the effectiveness of resource use in institutions of higher education. Particular attention was directed to the selection, screening, and certification of students for the use of private industry, government, and institutions of higher education themselves.

Selection is currently based primarily on measures of cognitive[3] abilities--grades,[4] achievement tests, and aptitude tests.

> . . . it is the unquestioned aim of almost every American college and university to upgrade the quality of its student body . . . The most widely used yardstick is the cutting point on the national College Entrance Examination Board (CEEB) score . . . The higher the median CEEB score, the happier administrators and faculty members are, because a high cutting point indicates that the less intelligent adolescents have been filtered out and the school is getting only the most promising ones.[5]

The most promising for what? Normally this means the most promising student, undergraduate or graduate. These measures of academic potential

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[3]The terms "cognitive," "affective," "academic," and "non-academic" are used rather loosely throughout the paper. Cognitive and affective are used to distinguish personal traits which Bloom [1956] describes in terms of educational objectives as follows:

> The cognitive domain . . . includes the objectives which deal with the recall or recognition of knowledge and the development of intellectual abilities and skills.
>
> The affective domain . . . includes objectives which describe changes in interest, attitudes, and values, and the development of appreciations and adequate adjustment.

The terms academic and non-academic are often used in referring to cognitive and affective traits, respectively. The distinctions are quite imprecise and should be interpreted accordingly.

[4]Grades may not measure only cognitive abilities. See Gintis [1971], for example.

[5]The Student in Higher Education, Report of the Committee on the Student in Higher Education, The Hazen Foundation, 1968. See also a report by the Commission on Tests of the CEEB [1970], Baird and Holland [1968], and Baird and Richards [1968].

are in fact rather good predictors of future academic success. In short, students tend to be selected on the basis of their promise as future students in the existing educational structure. Certification involves primarily the assigning of grades and degrees along with verification that a certain amount of time has been spent in school in general and in particular courses.

Several authors have suggested, however, that these measures are not correlated with job performance in many occupations, even though they may be used in occupational selection. The sociologist Ivar Berg [1970], for example, succinctly states his viewpoint in the title of his book, Education and Jobs: The Great Training Robbery. His findings, which relate primarily (but not exclusively) to blue collar workers, show little or no relationship between job performance and education. Another investigator, Hoyt [1965], reviewed 46 studies relating college grades and adult achievement in several areas--business, teaching, engineering, medicine, scientific research, miscellaneous occupations, studies of eminence, and non-vocational accomplishments. He concludes that "college grades bear little or no relationship to any measures of adult accomplishment." Similar conclusions have been suggested by others.[6]

The initial and primary focus of this paper is an examination of these conclusions when applied to a sample of individuals working in a large corporation, not unlike many others. This is done in Section 2 using salary as an indicator of job productivity. The absence of a significant relationship between academic achievement and job performance

[6] See, for example: Payne [1962], who remarks on studies by the National Advisory Committee for Aeronautics (now part of NASA) and Hughes Aircraft Company; Taylor and Ellison [1967]; MacKinnon [1962]; Goslin [1963]; Goslin [1968]; Wolfle [1965].

might be taken as a null hypothesis.

Further Questions.

According to human capital theory,[7] an individual chooses the occupation and level of education which maximizes the present value of his expected lifetime earnings. It is generally assumed that education changes an individual in such a way as to increase his capacity to perform various job related tasks. As demonstrated by Spence [1972], however, this need not be the case, theoretically. It is also implicitly assumed that the knowledge and other cognitive skills gained in school are the changes that increase his productive capacity.[8] But it may be that this is not the primary reason for observed differences in earnings by educational level. These income differentials may be the result, in part at least, of other factors associated with educational attainment: intelligence or academic aptitude, non-cognitive traits, or occupational entry requirements.

Several investigators[9] have attempted to control for intelligence in studies relating earnings to education. In general, these studies suggest a rather low contribution of intelligence (as measured) to earnings when level of education is controlled for.[10] This may, however, be due in part to occupational entry requirements based on level of education and limits on potential earnings within occupations. In addition, earnings

[7] See Becker [1964] or Thurow [1970]. The conventional theory is summarized by Weiss [1971] in a more recent article.

[8] In fact it may be explicitly stated. Becker [1964], for example, states: "On-the-job and school training are not the only activities that raise real income primarily by increasing the knowledge at a person's command," (p. 31). See also page 86 of the same source.

[9] See, for example: Griliches and Mason [1972]; Duncan [1968]; Bajema [1968]; Ashenfelter and Mooney [1968]; Hansen, Weisbrod, and Scanlon [1970].

[10] The study by Hansen, Weisbrod, and Scanlon [1970] is an exception.

may not be highly related to performance in occupations in which earnings are largely determined by established wage scales and promotions are based on seniority.

Gintis [1971] has argued that non-cognitive traits which lead to academic achievement are also required for success in bureaucratic organizations. He contends that it is these affective traits fostered by the educational experience (or at least rewarded by the educational system), and not cognitive development, which are largely responsible for the increased earning power of the more educated. He has no direct measures of affective traits, however. His argument also neglects credential requirements, which may limit the explanatory power of cognitive ability when educational level is controlled for. His argument would suggest a strong relationship between school grades and job performance, although Gintis seems not to make this point explicit.

Finally, there is the possibility that higher earnings of the more educated result in part from credential requirements which restrict entry to many occupations on the basis of educational level. Even in an extreme case in which (college) education did not change the productive capacity of students in any way, a positive relationship between earnings and education might be observed. Employers could rationalize the selection or payment of employees on the basis of educational level as long as the more educated were more productive on average. In general, what is required is that the cost of education to an individual be a decreasing function--or that the availability be an increasing function--of productive traits, that employers set wages to maximize expected profits, and that individuals choose an educational level to maximize expected earnings.[11]

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[11] Spence [1972] presents several examples in which the cost of education is related to a productive trait. Similar examples are presented by Arrow [1972].

For example, consider a case in which all productively relevant traits are affective traits determined solely by socioeconomic background and the personal cost of education is lower for children from wealthy families (which of course is the case). As another example, consider a situation in which traits needed to obtain high grades in high school are those needed for job success, but these traits are not altered by the college experience. Since persons with better high school grades are more likely to gain entrance to colleges, it would be rational to pay college graduates more than high school graduates, in the absence of other information. This possibility is perfectly consistent with the human capital hypothesis that individuals choose a level of education (within some opportunity set) to maximize future income, regardless of the relationship between education and productively relevant traits.

After examination of the relationship of measures of academic achievement and other personal characteristics to job productivity in Section 2, subsequent discussion in Section 3 will explore implications of the findings with respect to these questions.

The Data.

This attempt to provide partial answers to these questions is based on the performance of individuals with a given level of education working in a particular environment. The data pertain to individuals working in a large manufacturing corporation employing both technical and non-technical employees. In 1968, the corporation obtained biographical information as well as data on salary and position in the corporation of approximately 1,300 college graduates employed at that time. All were hired before 1965 and were not more than 30 years old when they joined the firm. Thus, most had little or no previous job experience. Those

surveyed represented a stratified (by function--manufacturing, finance, sales, etc.,--and hierarchical position in the firm) random sample of approximately 6,800 persons who met these requirements. Biographical information pertained to socioeconomic background, high school and college non-academic activities, academic performance (grades), college attended, employment goals, early employment experiences with the firm, and other personal characteristics. All biographical information except college attended was obtained by survey; only data on salary, position in the firm, and college attended were obtained from firm personnel records. Only persons hired after 1945 (employed less than 23 years) were included in the analysis because the relationship between salary and years employed differed markedly between this group and the group hired earlier.

The Measurement of Job Performance.

There seems to be no completely satisfactory way to measure job performance, or even of defining it. We therefore resort to the assumption that differences in individual job performance are reflected in measures of success within the firm; that rewards within the firm are based on job performance, or at least on perceived performance. In this case, there are two available measures of success: salary and grade level. Two models of individual experience within the firm are proposed below. The first is intended to be consistent with salary as a measure of success. If in fact, as is commonly assumed, an individual's lifetime earnings reflect his marginal product, the link between salary and job performance is rather direct. However, the relationship between individual attributes and reward by the firm is of interest whether or not earnings reflect marginal product. The second model is used with grade level as

a measure of success. It is based on the assumption that persons move through grade levels within the firm or leave the firm according to a Markov scheme and that relative job performance is reflected in the probability of promotion from one grade level to the next. This model emphasizes the uncertainty of individual progression (and salary) in the firm. Although the Markov model is thought to represent the more accurate description of individual experience, the results presented below may seem to emphasize the first model. The reason is that technical considerations make calculations based on this model much less expensive than those entailed in estimation based on the Markov model. The two models, of course, are not unrelated. The first model is used in Section 2, the second in Section 4.

Summary of Results.

The relationship between college quality and grades on the one hand and these measures of job performance on the other is not only statistically significant but is quantitatively important. Both the estimated rate of salary increase and the probability of promotion for persons from the best schools and with the highest grades are more than twice as high as those of persons from the poorest schools and with the lowest grades, even after controlling for non-academic characteristics. Thus, it would appear that criteria used for selection and certification are positively associated with an individual's ability to perform job-related tasks. The findings of the study also suggest that this relationship is not simply due to non-cognitive attributes such as motivation which may underlie academic success, but that academic achievement is an important determinant of job performance. This study, however, does not demonstrate the existence of such a relationship directly, but only provides indirect

evidence.

The results also suggest that non-academic attributes are just as important as academic abilities in determining job performance. Leadership ability and initiative (or job experiences allowing imaginative thinking or expression of one's ideas) are found to be positively associated with job performance, while a negative relationship is observed between an individual's desire for job security and his job success. An important characteristic of the sample data was the low correlation between academic and non-academic variables. Thus, identification of separate effects of these variables was not hampered.

2. Salary and Personal Attributes

Job productivity is assumed to be influenced by a variety of cognitive and affective traits, none of which is measured precisely by available data. Those variables assumed to reflect primarily academic aptitude or achievement are high school GPA (HSGPA), college selectivity (SEL), college GPA (GPA), and rank in graduate class for persons who obtained an M.A. degree after joining the firm. The variables assumed to reflect largely non-academic or affective characteristics require particular explanation and are discussed below. A "salary index" used in preliminary analysis is also described briefly. The model used and estimation results follow.

Salary Index.

Although not used in the regression analysis below, it has been found useful to have a relative measure of salary corrected for years employed. The "salary index" referred to in some instances is the

residual vector from a regression of salary on years employed for the whole sample, where a correction has been made for heteroscedasticity. The index thus has mean zero; the standard deviation is approximately 24.

Non-Academic Variables and the Summarization of Biographical Information.

Selected biographical questions asking for non-academic information, together with the type of response called for, are listed in Appendix Table 1. The questions have been grouped according to the type of information requested--socioeconomic background, leadership and organizational ability, initial work experience, initial supervisor, and job-related goals.

It is assumed that socioeconomic background affects not only the quality of education an individual obtains, but may also have some independent effect on non-academic traits which influence later job performance in a corporate (or bureaucratic) environment.[12] The information available is not, of course, a complete description of socioeconomic background.

The responses to leadership and organization ability questions are assumed to characterize, in part, an individual's past demonstrated ability as a leader or organizer.

Responses regarding initial experience in the firm may be interpreted in two ways. They may in fact indicate the existence of a particular kind of environment independent of the responding individual's behavior. But possibly a more plausible interpretation is that an individual responded positively or negatively to the questions according

[12] See for example: Ghiselli [1969], who emphasizes the importance of "perceived occupational level" as a determinant of managerial success. It would appear that this might be influenced by the socioeconomic background of one's parents. See also Robinson, et.al., [1969], and Winterbottom [1953].

to his evaluation of his personal behavior during his first years with the firm. For example, he did engage in imaginative thinking, he did use initiative, or he did make decisions on his own. The latter interpretation would suggest a direct link between the responses and personal traits.

Responses to questions about one's initial supervisor could be interpreted in a similar manner. They seem, however, to be less indicative of the respondent's behavior and more representative of his initial work environment.[13]

It appears from initial observation that there may be considerable duplication of information in the responses to questions within each of the first four groups. This suggests that the responses within each of these groups could be summarized in a smaller number of "indices" without losing a great deal of information. Further support for this approach is provided by observing that the mean of the salary index by response exhibits a similar pattern for all questions within each of the groups. The means for these and other questions are shown in Appendix Table 3. This procedure is not only convenient for expository purposes, but also avoids problems of collinearity which prevent distinction of separate effects on job performance of conditions presumed to be indicated by responses to the various questions. In addition, the intent of the study is not simply to predict job success, but to distinguish the effects of

[13] It may appear that the response to question 1 in this group simply indicates that a person was or was not promoted quickly during his first years with the firm, and would thus necessarily be correlated with salary or grade level. Since, however, there may be large differences in the extent to which supervisors push for promotions for persons under them, the response is likely to indicate a characteristic of his initial supervisor which could influence his attitude toward his job and thus his later performance.

different individual (or job environment) characteristics.

The information contained in the responses to questions (starred) under each of the first four headings has been summarized in a single index by means of principal components analysis.[14] The indices are linear combinations of responses to questions within groups, where the weights are selected to be optimal according to a particular criterion. The resulting indices are referred to as: socioeconomic index (SES), leadership and organizational ability index (LEAD), initial experience--or initiative index (INT), and initial supervisor index (SUP).

In fact, all principal components relative to each group were calculated and the possibility of using more than one index for each group was explored. It was found, however, that very little could be gained by using additional components. Also, principal components were calculated

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[14] Let X be an $(r \times 1)$ random vector, representing for example the responses of an individual to a group of questions. We would like to reduce the dimension of X (to a t-dimensional vector, $t < r$) in such a way as to lose as little information as possible according to a particular criterion. The criterion being that we can estimate the original vector from the vector of reduced dimension in such a way as to minimize the following expression:

$$\min_{D,C} E(X - DCX)'(X - DCX) \text{ , where}$$

E indicates expected value,

C is a $(t \times r)$ matrix, and

D is an $(r \times t)$ matrix.

Here, CX is the vector of reduced dimension and D is a matrix of coefficients such that $D[CX]$ is an r-dimensional vector which is intended to approximate the original vector x. The expression is minimized by choosing C such that its rows are the first t (ordered by the magnitude of the corresponding eigenvalues) eigenvectors of Σ_{xx}, the covariance matrix of X. In our case, $t = 1$ and CX is the first principal component representing the index used for a particular group of variables. In addition, the variables have been normalized to have unit variance and mean zero so that Σ_{xx} represents a correlation matrix. This avoids the problem of having the weights influenced by the variance of the respective variables. Of course, a sample analog of the above description has been used for purposes of calculation. See, for example, Rao [1965].

using all the variables within each group and using subsets of these variables. Components were also obtained for variables in groups III and IV combined. On the basis of results from these preliminary calculations, only the responses to the starred questions were used in constructing the indices.

We may evaluate the information loss involved in this procedure in two ways. One is to use the proportion of total variation (percent of the trace of the appropriate correlation matrix) explained by the first principal component. A more informative measure in this case, however, may be the information loss relative to the potential of these variables to explain salary increases. To do this, we have found the correlation between the salary index and each of the first principal components and the multiple correlation between the salary index and all of the variables (starred) in each group. This was done by regressing the salary index on all of the variables. Comparative results for each group are shown in the following tabulation.

Index	Multiple Correlation (1)	Principal Component Correlation (2)	(1) - (2)
SES	.193	.168	.025
LEAD	.246	.239	.007
INT	.323	.290	.033
SUP	.230	.223	.007

The response to the first question under group V has been used as a single variable indicating an individual's desire for job security (SEC). This variable may be interpreted in two ways. First, as a measure of risk aversion. The higher a person progresses in the firm hierarchy, the greater is the likelihood that he will have to make decisions, the consequences of which are traceable to him. These decisions may ultimately

be shown to be correct or incorrect with a corresponding possibility of assessment of his capabilities by the firm.[15] In order to advance, however, he must take this chance. A second possibility is that the response simply reflects an individual's confidence or "self-assurance."[16] Persons who are not worried about job security may feel confident that they can make the right decisions. Or, their personalities may be such that they are not afraid to "put themselves on the line" and run the psychological risk of being wrong or of having their decisions--and thus their capabilities--openly evaluated by others.

The Correlation between Academic and Non-Academic Variables.

The correlations between selected variables are shown in Table 1. It may be seen that the correlations between academic and non-academic variables (excluding SES) are quite small in most cases.[17] Thus the two groups of variables seem to reflect largely independent individual (or job environment) attributes. It may also be noted that the correlation between SES and HSGPA is surprisingly low. This sample, of course,

[15] In this regard, a firm employee stated that at particular grade levels, persons tend to come under "scrutiny" by higher management.

[16] See Ghiselli [1969].

[17] This is consistent with the findings of other investigators. See, for example, Getzells and Jackson [1961] and MacKinnon [1962] who find weak relationships between intelligence and creativity; Holland and Richards [1965], Holland and Nichols [1964], and Holland and Richards [1966] who find that academic and non-academic (extracurricular) achievement in high school and college are "relatively" independent. Similar evidence is provided by Baird and Holland [1968]; and Flanagan, et.al., [1964].

The highest correlations here are between SEC and SEL (a negative correlation), and SUP and MA rank. A possible interpretation of the first is that persons with more confidence or self-assurance are more likely to enter better schools, because of this quality. Another, although I think less plausible, is that persons who go to better schools develop these traits to a greater extent than those who go to lower quality schools. The second may indicate some differential treatment by supervisors of persons going to school while working, depending on how well they are doing in school. It might also indicate some influence of one's supervisor on motivation to do well in graduate school.

TABLE 1

Correlation Matrix, Selected Variables

	Salary Index	Years Employed	SES	HSGPA	SEL	GPA	MA	MA Rank	SEC	LEAD	INT	SUP	INT+ SUP
Salary Index	1												
Years Employed	.057	1											
SES	.151	.006	1										
HSGPA	.226	.059	.060	1									
SEL	.286	.118	.220	.247	1								
GPA	.244	.065	-.008	.315	.042	1							
MA*	.223	-.057	.069	.086	.170	.173	1						
MA Rank**	.213	-.070	.123	.260	.048	.204	--	1					
SEC	-.300	-.002	-.131	-.082	-.200	-.111	-.129	-.081	1				
LEAD	.255	.008	.121	.128	-.006	.124	.019	.065	-.129	1			
INT	.280	.023	.021	.041	.065	-.012	.034	.027	-.061	.035	1		
SUP	.215	.056	.071	.041	.075	.032	.062	.229	-.033	.064	.536	1	
INT+SUP†	.291	.036	.039	.045	.079	.000	.047	.097	-.061	.050	.966	.735	1

*A dichotomous variable indicating whether an individual did (1) or did not (0) obtain an M.A. degree after joining the firm.

**Indicates rank in graduate class if an individual obtained an M.A. Thus correlations refer only to persons who got an M.A.

†First principal component of the two groups combined.

is not representative of the entire population.[18]

The Model.

In what follows it is implicitly assumed that differences between individuals in expected lifetime earnings reflect differences in the performance of tasks considered to be important to the functioning of the firm. Those who "do better" are rewarded with higher incomes. A more conventional assumption would be that the marginal product[19] of a person who stays in the firm is given by his expected lifetime earnings. The results below, however, are in no way dependent on an individual being paid the value of his marginal product.

Let us assume that the monthly salary of a person who has been employed by the firm for t years is given by,

$$s = e^{a} e^{rt} e^{\varepsilon} ,$$

where e^{a} represents starting salary, r is the rate of increase in monthly salary, and ε is a disturbance term. Both a and r are assumed to be functions of personal characteristics:

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[18] A possible explanation for the result here is as follows. Assume that SES influences one's "perceived occupational status" and thus his desire for education after high school. This in turn affects his performance in high school. It might be argued, however, that the perceived occupational status of persons in this group does not differ greatly, since all of them went to college. If this were the case, a low correlation between SES and HSGPA within this group would be expected.

[19] His marginal product would of course depend on how he and others in the firm were used. This assumption would also imply that persons with different attributes are used by the firm in an optimal manner. Given constraints on the firm, it would place persons of different abilities in different successions of jobs so as to maximize the aggregate contribution of all those employed. If we then think of a person being paid his marginal product over his lifetime, we are assuming marginal product given the way in which he is used by the firm relative to all other employees. Given that a person of given attributes is used in a particular way during his years of employment, another person of like attributes would be used in the same way and would thus have the same marginal product. The Markov model presented below implies that this is only approximately true at best.

$a = g_0(x)$, and

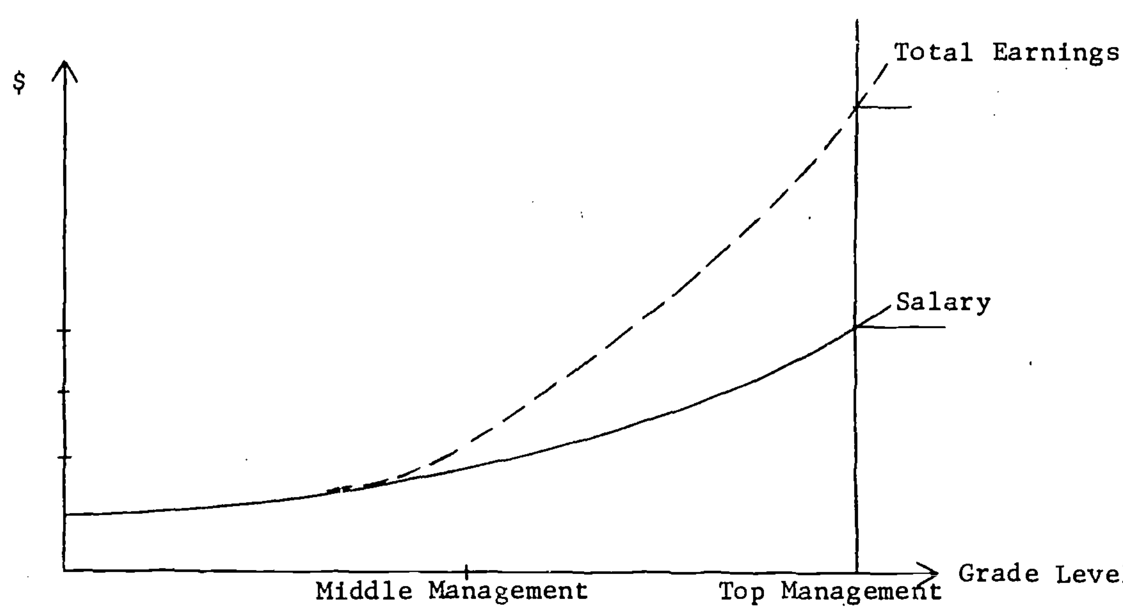
$r = g_1(x)$,

where x is a vector of individual (and possibly job environment) attributes.

Data are available on salary only, which may comprise only a portion of total income from the firm. As one rises in the firm hierarchy, bonuses and stock options are likely to comprise an increasingly large portion of total income and may even be more important than salary at very high levels. (This is one motivation for looking at grade level, instead of salary, as a function of personal attributes, as is done in a later section.) It might be assumed, however, that the relationship between total earnings (E) and salary (s) is one of the following form:

$$E = s^k$$

where k is some constant greater than one. Non-salary earnings are of course likely to vary from year to year and among individuals, but this relationship is assumed to be representative of the average. The relationship, for example, may look something like that shown on the adjacent graph.[20]



[20]The relationship between grade level and salary is shown to be non-linear since that appears to be the relationship in this firm as well as

In this case, the use of total earnings instead of salary would not affect qualitatively the estimates of the parameters, a and r. They would simply be increased by a factor of k. Differences in total lifetime earnings among individuals would, of course, be much larger than differences in lifetime earnings from salary.

The estimated model is of the form:

$$s = e^{a}e^{rt}e^{\varepsilon}\ , \text{ or } \ \ell n\ s = a + rt + \varepsilon\ ;$$

$$a = a_0 + a_i + b_j + dx_o \qquad \text{(Model I)}$$

$$r = r_o + \alpha_i + \beta_j + \gamma_k + \Sigma_{\ell=1}^{5}\ \delta_\ell x_\ell\ ; \text{ where}$$

$$\Sigma_i a_i = 0,\ \Sigma_j b_j = 0,\ \Sigma_i \alpha_i = 0,\ \Sigma_j \beta_j = 0,\ \Sigma_k \gamma_k = 0\ .$$

The symbols are defined in the list below. The corresponding variables (or categories) will henceforth be referred to by the mnemonic abbreviations beside the symbols.

Constant	a_0	≡ constant;
BA	a_1	≡ effect of having BA degree when start work at the firm;
BA'	a_2	≡ effect of not having BA degree when start work at the firm;
ENG	b_1	≡ effect of engineering or science undergraduate major;
LIB	b_2	≡ effect of liberal arts (or other) undergraduate major;
BUS	b_3	≡ effect of business undergraduate major;
EXP	x_0	≡ years of experience (excluding military) before coming to the firm;

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in others. In fact, the relationship between grade level, g, and average salary, s_g, in that grade would be well represented by a function of the form

$$s_g = \beta^g s_o\ ,$$

where β is a constant greater than one, and s_o is the average salary in the starting grade. This form is suggested by Williamson [1970], for example.

AV	r_0	$\equiv$ "average" rate of salary increase;
SEL(i)	α_i	$\equiv$ effect of undergraduate college in i^{th} selectivity group;
GPA(j)	β_j	$\equiv$ effect of undergraduate grades in j^{th} interval;
MA(k)	γ_k	$\equiv$ effect of being in k^{th} rank in MA class (γ_0 is for BA only);
SEC	x_1	$\equiv$ index of desire for job security;
SES	x_2	$\equiv$ socioeconomic background index;
LEAD	x_3	$\equiv$ leadership and organizational ability index;
INT	x_4	$\equiv$ initial job experience index;
SUP	x_5	$\equiv$ initial supervisor index.

The last five variables have been discussed above. They are treated as continuous. The others may be explained briefly. A few[21] persons reported their age at the time they joined the firm as less than their age when they received a bachelor's degree. Hence, the category BA' . Information on job experience before joining the firm was not available. The variable EXP is a crude estimate[22] made from available information.

Colleges were assigned to groups, SEL(i) , on the basis of Astin's

[21] There were 72 out of the 1,027 persons in the sample employed less than 23 years and who did not have a degree when they joined the firm. Of the 1,027, those used in the calculations below numbered 976. The large majority of those not having the B.A. obtained it shortly (less than 3 years) after joining the firm. It is possible that some were only working part-time before they obtained a B.A. degree.

[22] The estimate was obtained as follows: Let x equal the age of an individual when he joined the firm minus his age when he obtained a B.A. degree. Then, EXP was estimated to be: $x - 2$ if $x \geq 3$ and person had military service; and x if he had no military service or if he had military service but $x \leq 2$. Thus if x was greater than 2, it was assumed that military service came after college, which may not have been the case. This would tend to understate previous experience in some cases. Also, it was not possible to distinguish persons who got a B.A. at age 25 from those who got a B.A. at any age greater than 25; all were assumed to have obtained the B.A. at 25. In some of these cases, previous job experience would be overstated.

[1965b] college selectivity index.[23] This index is intended as a "measure of the average ability level of the entering class." In order to have groups with a reasonable number of persons in each, it was necessary to choose intervals of the index, which define the groups, rather arbitrarily.[24] A few index numbers represented colleges attended by a disproportionate number of persons in the sample, although the whole range of selectivity rankings was represented.

The GPA intervals are those designated in the firm survey.[25] The designation MA(k) refers to rank in graduate school for those who obtained an MA after joining the firm. Of these persons, those in group MA1 graduated in the top 5 percent of the graduate class, MA2 in the top one-third of their graduate class, and MA3 in the lower two-thirds of their class.

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[23] The index is defined by the total number of highly able students who want to enroll at the college divided by the number of freshmen admitted. It was obtained by asking Merit Finalists and recipients of the Letter of Commendation to name the two colleges they would most like to attend. The index represents the number of these students choosing a given college as a percent of the total number of students admitted, after normalization (mean 50 and standard error 10). See Astin [1965b]. The index is highly correlated with the average SAT scores of entering freshmen. Astin [1965a] obtained a correlation of .88 using SAT scores of students enrolled at 105 institutions in 1960. Average SAT scores of students attending colleges in the firm sample were obtained from Astin [1971]. Most pertain to the years 1966 or 1967. The correlation between SAT scores and SEL scores for the firm sample was .86. Since some schools represented in the firm sample were not assigned SEL scores by Astin, the SEL scores were estimated by their SAT scores (by means of regression analysis). Both SEL and SAT scores were experimented with in this study, with similar results. The SEL index was ultimately used because it was felt that it was likely to be more representative of the colleges when they were attended by the bulk of the persons in the firm sample. The SEL scores are based on 1961-63 data as opposed to 1966-67 for the SAT scores.

[24] The groups and corresponding intervals are as follows: SEL1, 73-79; SEL2, 66-72; SEL3, 61-65; SEL4, 56-60; SEL5, 47-55; SEL6, 37-46.

[25] Respondents selected the appropriate interval. The groups and corresponding intervals are: GPA1, 3.50-4.00; GPA2, 3.00-3.49; GPA3, 2.50-2.99; GPA4, less than 2.50. GPA4 combines the lowest two intervals as designated on the survey.

The designation MAO represents those with a B.A. degree only.

It may be noted that the model as stated does not allow SEL or GPA to enter into the determination of starting salary. This is not an arbitrary assumption but is based on previous analysis of the data. This analysis is discussed in Appendix I. Models allowing prior military service to influence starting salary and undergraduate major to affect the rate of salary increase were also tried. These factors seemed to be of no appreciable importance and were eliminated from later analysis.

In addition, the model as stated does not allow for interactions between SEL and GPA (or between MA and SEL or GPA). To allow for interactions with 6 SEL groups and 4 GPA groups would require the estimation of 15 additional independent parameters, and would result in SEL/GPA cells with very few observations. The significance of interactions was, however, tested for in a model with only three SEL and three GPA groups. Results from this model are presented below. Interactions were shown not to be statistically significant in this case, and it has been implicitly assumed that they would not be significant if they were included in the model with more SEL and GPA groups.

Finally, the model assumes a constant rate of salary increase over an individual's working lifetime. It is normally assumed that the rate of increase decreases and may become negative at some point. It should be remembered, however, that the available data pertain to persons employed no longer than 22 years.

Results.

Estimates of the parameters in Model I, obtained by ordinary least squares,[26] are shown in Table 2. The F-statistics pertain to the null

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[26] One would expect the variance of the error term in a regression

hypothesis that the parameters indicated are all zero, which in the case of the discontinuous variables is equivalent to the hypothesis that the effects are the same for all groups (e.g., SEL(i) is the same for all i). In each case, the hypothesis is rejected at any reasonable level of significance.[27] Estimates above the double line relate to determinants of starting salary, a , and those below to the rate of increase in salary, r .

The estimates regarding starting salary confirm what might be expected. Persons with a B.A. had a higher initial salary than those who started work before obtaining a degree, although the difference seems quite small ($837 versus $795 by taking the anti-logs of 6.70356 ± .02591). This is probably due to the fact that most persons who didn't have a degree when they joined the firm obtained it a short time later. The estimates also indicate that persons whose undergraduate major was engineering or a science commanded higher initial salaries than those who majored in liberal arts or business.

A comparison of the estimates for EXP and AV indicates the relative value the firm places on experience prior to joining the firm versus experience in the firm. According to these estimates, the average person (for whom the values of all other variables are equal to their sample means) with z years of experience outside the firm would receive an initial salary of $ke^{.016z}$ (where k is a constant) while a similar

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of salary on the right-hand-variable included here to increase with years employed, suggesting that generalized least squares should be used. Using $\ell n\ s$ instead of s tends to reduce the problem of heteroscedasticity; but does not eliminate it, judging from a plot of residuals against years employed. Attempts to correct for this, however, did not appreciably alter the parameter estimates or their standard errors.

[27] $F_{.01}(5, 976) = 3.02$, $F_{.005}(5, 976) = 3.35$.

TABLE 2

Parameter Estimates, Total Sample

Variable	Estimated Coefficient	Standard Error*	F-Statistic
Constant	6.70356		
BA BA'	.02591 -.02591	(.01079) (.01079)	F = 5.766
ENG LIB BUS	.03879 -.01340 -.02539	(.00764) (.00956)	F = 16.018
EXP	.01647	(.00315)	
AV	.04501	(.00171)	
SEL1 SEL2 SEL3 SEL4 SEL5 SEL6	.01085 .00234 .00122 -.00183 -.00431 -.00827	(.00308) (.00119) (.00147) (.00091) (.00116)	F = 10.781
GPA1 GPA2 GPA3 GPA4	.00777 .00055 -.00245 -.00587	(.00131) (.00087) (.00073)	F = 22.179
MA1 MA2 MA3 MA0	.01241 -.00017 -.00504 -.00720	(.00311) (.00182) (.00193)	F = 11.398
SEC SES LEAD INT SUP	-.00310 .00030 .00218 .00070 .00142	(.00045) (.00031) (.00027) (.00025) (.00035)	F = 41.893
N = 976 R^2 = .69029			

*The standard error for the estimate of the effect of being in the lowest interval of a variable (e.g., SEL6) is not shown because the computer program used did not compute a variance-covariance matrix.

person with z years of experience within the firm and no previous experience would be earning an amount $ke^{.045z}$. Although the coefficient on EXP may be underestimated, it might be expected to be quite low, because the previous experience for many people in the sample may have been in work unrelated to that of the firm. In addition, part or all of the estimated previous "experience" for an individual could have been time spent without a job (after college) or time spent looking for work. In any case, the estimated coefficient should be interpreted cautiously.

The average[28] rate of increase in salary is estimated to be .045. The meaning of the other estimates may be demonstrated by an example. The estimated rate of increase for a person who went to a college in SEL group 2 had college grades in GPA group 1, and did not obtain an MA degree would be given by .045 + .002 + .008 - .007 , assuming that the values of the continuous variables equal their means (zero).

With this interpretation in mind, it is seen that the estimated rate of salary increase goes up consistently with college selectivity, college grades, and rank in graduate class (if an MA is obtained). The relationships, however, are seen to be non-linear. The difference between SEL2 and SEL1 is much larger than any of the other increments between SEL groups. There is a relatively large decrease in going from SEL5 to SEL6.[29] The estimated GPA effects indicate that the increase in

[28]The continuous variables SEC, SES, LEAD, INT and SUP have zero means by construction. Also $\Sigma SEL(i) = \Sigma GPA(j) = \Sigma MA(k) = 0$. Thus, for example, the sum of the estimated SEL effects over all persons in the sample, where each estimate is weighted by the number of persons in the corresponding group, is zero. The same is true for the GPA and MA estimates. So that, $\Sigma[(1/N)r_o + (1/N_i)\alpha_i + (1/N_j)\beta_j + (1/N_k)\gamma_k + \Sigma\delta_\ell x_\ell] = r_o$, where the summation is over all persons in the sample and N_i is the number of persons in the i^{th} SEL group, etc. In this sense, the estimate for AV is a weighted average.

[29]The apparent non-linearity may result in part from the way in which the selectivity index was standardized (Astin [1965b]).

going from GPA2 (3.00-3.49) to GPA1 (3.50-4.00) is also disproportionately large. The relatively large standard errors of the estimates for SEL1 and GPA1 reflect the relatively small number of persons in these groups. The estimates, especially for SEL1, must be interpreted accordingly.

The effect of graduate education after joining the firm can be seen by combining the estimates for AV and MA(k). The average rates of increase by rank in graduate class are as follows:

Rank in Graduate Class	Estimated Rate of Salary Increase
Top 5 percent	.057
Top 1/3, excluding top 5 percent	.045
Bottom 2/3	.040
BA only	.038

According to these estimates, obtaining an MA degree has almost no effect on an individual's rate of salary increase, unless he graduates at least in the top third of his class. In order to realize a sizeable increase, he must graduate in the top 5 percent. Simply obtaining a certificate has no appreciable effect.

From the parameter estimates in Table 2, the implied rates of salary increase by SEL/GPA group for persons with a B.A. degree only have been calculated. They are shown in Table 3. The estimate in the i^{th} column and the j^{th} row is obtained as follows: AV + MAO + SEL(i) + GPA(j) . It may be seen that the estimated rate for persons from the highest selectivity schools and with the highest grades is approximately twice as high as the rate of increase for persons from the lowest selectivity schools and with the lowest grades. These, of course, are not independent estimates. Independent estimates for fewer categories are presented below. As will be shown, the general pattern remains the same.

TABLE 3

Estimated Rates of Salary Increase for Persons with a BA Degree by College Selectivity-College GPA Group*

	SEL 1	SEL 2	SEL 3	SEL 4	SEL 5	SEL 6
GPA 1	.05643	.04792	.04680	.04375	.04127	.03731
GPA 2	.04921	.04070	.03958	.03653	.03405	.03009
GPA 3	.04621	.03770	.03658	.03353	.03105	.02709
GPA 4	.04279	.03428	.03316	.03011	.02763	.02367

*Calculated from estimates in Table 2, [AV + MA_0 + SEL(i) + GPA(j)] .

The estimates of the parameters corresponding to the non-academic variables are all significant except the coefficient on SES. Apparently, the effect of SES is only by way of its effect on academic achievement. The coefficient on SES is significant when SEL is left out of the equation.

One way to evaluate the relative influence of the continuous variables is to compare the change in the rate of salary increase, Δr , resulting from an increase in a given variable equal to the sample standard deviation of that variable, with the change resulting from comparable increases in the other variables. These calculations are presented in the following tabulation.

Variable	Sample Standard Deviation	Δr
SEC	1.130	-.00350
SES	1.452	.00044
LEAD	1.557	.00339
INT	2.113	.00148
SUP	1.487	.00211

It may be noted that the change due to a standard deviation increase in SEC or LEAD is approximately the same as the increase resulting from a shift from GPA4 to GPA3 or from GPA3 to GPA2. The effect of INT and SUP is considerably weaker. This might be expected since the latter variables presumably pertain only to an individual's initial experience in the firm. The direct effects of characteristics presumably measured by these results may tend to disappear as the number of years employed increases.[30]

[30] The appropriate interpretation of these variables is also less clear than that of LEAD of SEC. If, for example, INT is assumed to measure initiative, it may do so with considerable error, thus tending to "bias" the estimated coefficient toward zero. In other words, the extent of the error in variables with respect to INT and SUP is likely to be larger than for SEC and LEAD.

An idea of the relative contribution of academic versus non-academic variables in the "determination" of salary may be obtained by comparing values of R^2 obtained when groups of variables are excluded from the regression. The results of this procedure are shown in the following tabulation.

Right-Hand Variables Included	R^2
(1) - All Variables	.690
(2) - t (years employed)	.490
(3) - t, BA, BA', EXP, ENG, LIB	.530
(4) - (2), (3), SEL(i), GPA(j), MA(k)	.622
(5) - (2), (3), SEC, SES, LEAD, INT, SUP	.633

The percent of the variation remaining unexplained after variables (3) are included, which is explained by the academic and non-academic variables together is .340. A high estimate of the contribution of academic variables is the proportion of remaining variance explained when they are added to the regression in the absence of non-academic variables. A low estimate is the addition to the proportion explained when they are added after the non-academic variables.[31] In this case, the high and low estimates are [(4) - (3)]/[1 - (3)] and [(1) - (5)]/[1 - (3)] , respectively. The opposite is true for the non-academic variables. Carrying out these calculations yields the following results:

Academic Variables		Non-Academic Variables	
Low	High	Low	High
.121	.196	.145	.219

[31] The two estimates would be the same, of course, if the two groups of variables were orthogonal. In this case, the most highly correlated variables are SES and SEL (-.22), SEC and SEL (.20), and SUP and MA(k) (.23).

SEL-GPA Interactions.

To test for the presence of SEL-GPA interactions, a model with three SEL and three GPA categories, and allowing for interactions, was estimated. In this case, the rate of salary increase takes the form:

$$r = r_o + \alpha_i + \beta_j + (\alpha\beta)_{ij} + \gamma_k + \Sigma^5_{\ell=1}\delta_\ell x_\ell \text{ , where}$$

$$\Sigma\alpha_i = \Sigma\beta_j = \Sigma\gamma_k = \Sigma_i(\alpha\beta)_{ij} = \Sigma_j(\alpha\beta)_{ij} = 0 \text{ , and}$$

$(\alpha\beta)_{ij}$ is the effect of attending an undergraduate college in the i^{th} selectivity group and having obtained an undergraduate GPA in the j^{th} interval. Estimates of selected parameters from this model, together with estimates of the rate of salary increase for B.A. holders, are shown in Table 4. The null hypothesis $H_o : (\alpha\beta)_{ij} = 0$ for all i and j cannot be rejected at any reasonable level of significance.[32] In fact, none of the individual interaction estimates was close to being significantly different from zero.[33] This was the motivation for increasing the number of SEL and GPA groups while ignoring the possibility of interactions, in the previous model. The additional categories allowed revelation of non-linearities which are not revealed when only three GPA and three SEL groups are distinguished. When the extreme groups (SEL1, SEL6, and GPA1) are combined with adjacent groups, the disproportionate effect of being in one of these groups is not seen.

But with fewer groups and more observations per group, we obtain more precise estimates. In addition, the estimates of rates of increase in

[32] The F-statistic is .1898. For comparison, $F_{.10}(4,976) = 1.94$.

[33] The estimates for $\hat{\alpha}_i + \hat{\beta}_i + (\hat{\alpha\beta})_{ij}$, however, suggest the presence of some interaction at high SEL and high GPA levels. Comparing the differences between rows and columns by cell, we find relatively large differences with respect to the SEL1-2/GPA1-2 cell.

TABLE 4

Estimates of Selected Parameters, and Rates of Salary Increase* by SEL-GPA Group, Allowing for SEL-GPA Interactions

TABLE 4-a

SEL(i) + GPA(j) + SEL-GPA(ij) : $\hat{\alpha}_i + \hat{\beta}_j + (\hat{\alpha\beta})_{ij}$**

	SEL 1-2	SEL 3-4	SEL 5-6
GPA 1-2	.00960 (.00188)	.00371 (.00109)	.00007 (.00161)
GPA 3	.00359 (.00155)	-.00012 (.00098)	-.00512 (.00129)
GPA 4	.00013 (.00192)	-.00358 (.00100)	-.00828

TABLE 4-b

AV + MAO + SEL(i) + GPA(j) + SEL-GPA(ij) : $\hat{r}_o + \hat{\gamma}_o + \hat{\alpha}_i + \hat{\beta}_j + (\hat{\alpha\beta})_{ij}$

	SEL 1-2	SEL 3-4	SEL 5-6
GPA 1-2	.04395	.03806	.03442
GPA 3	.03794	.03423	.02923
GPA 4	.03448	.03078	.02607

TABLE 4-c

Other Parameters

AV : $\hat{r}_o$ = .04135 (.00160)	SEC : $\hat{\delta}_1$ = -.00308 (.00046)
MA1 : $\hat{\gamma}_1$ = .01205 (.00315)	SES : $\hat{\delta}_2$ = .00044 (.00031)
MA2 : $\hat{\gamma}_2$ = -.00038 (.00185)	LEAD : $\hat{\delta}_3$ = .00227 (.00028)
MA3 : $\hat{\gamma}_3$ = -.00467 (.00196)	INT : $\hat{\delta}_4$ = .00071 (.00025)
MAO : $\hat{\gamma}_4$ = -.00699	SUP : $\hat{\delta}_5$ = .00147 (.00036)

*For BA holders.

**The standard errors were obtained by estimating the model with r specified as: $r = r_o + c_{ij} + \gamma_k + \Sigma_\ell \delta_\ell x_\ell$, where c_{ij} is the effect of being in the i^{th} SEL group and the j^{th} GPA group (i.e., main effects and interactions are not distinguished). This is equivalent to the model as specified above--i.e., $\hat{c}_{ij} = \hat{\alpha}_i + \hat{\beta}_j + (\hat{\alpha\beta})_{ij}$.

Table 4-b may be considered more reliable than those in Table 3, since we have nine independent estimates in Table 4-b. The general pattern revealed by the two tables, however, is the same.

Finally, it may be seen that the only non-academic coefficient which changes substantially is the SES coefficient. This results from limiting the effective range of SEL. Part of the effect of being in extreme SEL groups is picked up by SES. The coefficient is still not significant.

Undergraduate versus Graduate School Achievement.

Further insight into the relationship between salary progress and graduate education may be gained by considering the mean of the salary "index" by undergraduate GPA and rank in graduate school. This procedure is also a means of checking for the presence of GPA-MA interaction effects on salary. These figures are presented in Table 5. They essentially confirm the findings presented in Tables 2 and 4. That is, if we control for an individual's performance in graduate school, relative to his classmates, his undergraduate record is still positively associated with salary. These figures, however, suggest the presence of interaction effects, especially in the case of business majors. It was not possible to take account of interactions in the analysis of variance framework because of the small number of observations involved. The estimates for the total sample, Table 2, would probably not have been significantly affected by interactions in any event, judging from the figures for all MA's in Table 5.

Other variables, of course, have not been controlled for in making these estimates. It might be assumed, for example, that persons with better undergraduate records were able to get into better graduate schools and that the difference in salary by undergraduate GPA is partially the result of this effect. Since, however, these persons obtained an MA at

TABLE 5

Mean of Salary "Index" by Undergraduate Major and GPA-MA Group for Persons Who Obtained an MA Degree*

	Total Sample		Engineering or Science		Business	
	MA1-2	MA3	MA1-2	MA3	MA1-2	MA3
GPA1-2	23.26 (4.12) [30.53] n=39	10.85 (4.12) [26.54] n=15	34.97 (7.75) [40.27] n=13	18.78 (10.55) [33.45] n=7	16.04 (4.90) [25.20] n=21	2.23 (10.04) [18.05] n=5
GPA3-4	11.90 (4.29) [18.89] n=36	3.44 (4.48) [25.55] n=33	20.91 (7.21) [17.89] n=15	0.50 (7.21) [19.31] n=15	5.29 (5.61) [19.34] n=16	1.91 (6.23) [22.54] n=13
	Total: 13.10 [26.53] n=123		Total: 18.14 [30.08] n=50		Total: 8.31 [22.70] n=55	
	R^2 = .084		R^2 = .190		R^2 = .076	
	$F(3, 119) = 3.65$		$F(3, 46) = 3.62$		$F(3, 51) = 1.40$	

Model: $e_{ijk} = \beta_{ij} + \varepsilon_{ijk}$, where e_{ijk} is the index number for k^{th} person in the ij^{th} GPA-MA group.

*The index is the residual from a regression of salary on years employed where a correction has been made for heteroscedasticity. The total sample was used in this regression. Figures for liberal arts majors are not shown because of the small number of observations in each cell. Numbers in parentheses are standard errors of estimates. Numbers in brackets are within group sample standard deviations. The number of observations in the group is n.

the same time that they were working, it is likely that the best graduate schools were not represented in the sample and that the difference in the quality of those represented was not large.

Finally, these figures suggest a considerably larger effect of the MA on earnings for engineers or scientists than for business majors. It is assumed that most of the MA degrees were in fact MBA degrees. In this case, one might expect a stronger effect for engineers because of the relatively unique combination of technical and managerial skills which they might be expected to possess.

Additional Results.

Estimates of Model I by undergraduate major and firm function were obtained and are discussed in Appendix II. Since these results do not alter the general conclusion reached above, they are summarized only briefly here. The most striking difference between the results for engineering (or science) and business majors is the smaller effect of SEL for engineers. The effect of GPA is also somewhat smaller for engineers. It is hypothesized that these results are due to a smaller difference in academic aptitude between schools for engineers than for business majors, and the relatively stringent academic requirements within engineering schools. The effect of GPA is found to be least important for liberal arts majors. This is consistent with the assumption that liberal arts training is less directed toward job relevant skills than either engineering or business programs. The results by function show that GPA is most important in engineering and finance, both of which are considered to be relatively demanding fields academically. Neither GPA nor SEL are significant in the industrial relations function. This also is consistent with *a priori* judgments. In all majors and functions, SEC and LEAD are

significant while SES is significant in none.

3. Further Implications

The above analysis has been directed primarily toward the following question. What is the relationship, if any, between academic achievement of college graduates and job performance (or productivity) outside the educational system? And further, what is the relative importance of academic achievement and other non-academic attributes of individuals? It has been shown that there is a consistent positive relationship between commonly used measures of academic achievement and rates of salary increase in a particular large corporation. In addition, it has been found that, of those attributes of individuals that have been controlled for, academic and non-academic characteristics seem to be of approximately equal importance in explaining differences in salary. Both, however, explain a relatively small proportion of the total variation in salary. This should not be surprising, since the individuals all had the same quantity of education when they started work and all were presumably selected with the expectation that they would be able to perform at least adequately. The model proposed in the next section explicitly implies a limit on the explanatory power of individual attributes.

In addition to the above rather straightforward findings, the results may also provide some insight into the more difficult, and more fundamental, questions that were posed in Section 1 of the paper. The implications with respect to these questions are less clear than the implied relationship between academic achievement and job productivity. They essentially ask why this relationship is observed.

In the discussion of these questions, it is useful to have in mind

a model describing the determinants of an individual's academic experience and his job performance. Such a model is proposed informally in the following diagram. Arrows imply causal relationships and equality signs indicate non-causal relationships. Unattached arrows indicate the influence of unspecified factors.[34] The model is not intended to be exhaustive, but only to indicate basic broad relationships. It may be noted that "intelligence," which is thought of loosely here as academic aptitude, has been allowed to change as one moves through the academic system. Academic aptitude is assumed to be a measure of "intelligence," which may be independent of academic achievement as measured by GPA or achievement test scores.

The estimated model is an attempt to capture the essence of relation (6), but it does so with some imprecision. Only limited indicators of job environment are available--SUP and possibly INT. Affective traits are assumed to be reflected in SEC and LEAD and possibly SES and INT. But these certainly represent only a few of the non-cognitive characteristics which are important determinants of job performance. Academic aptitude and academic knowledge are assumed to be represented by SEL and GPA; but as the diagram indicates, both measures are likely to represent a combination of aptitude and knowledge. They may also reflect affective traits associated with getting good grades or going to different colleges. An independent measure of academic aptitude (e.g., a test score) is not available, nor is an independent estimate of knowledge of academic subject

[34]A more formal specification would present these relationships in the form of a recursive system. Theoretically, such a system could be estimated equation by equation, assuming independence of error terms, to obtain unbiased coefficient estimates. This has not been attempted since adequate measures of many of the variables (e.g., test scores) are not available.

Period 0	Innate Intelligence			
	Socioeconomic Background			
Period 1	Socioeconomic Background	→	Affective Traits 1	
Period 2	Innate Intelligence Affective Traits 1	→	High School GPA	(1)
	Socioeconomic Background Affective Traits 1	→	Affective Traits 2	(2)
	{High School GPA High School Quality}	=	(Academic Knowledge 2) + (Error)	(a)
	{High School GPA Achievement Test Score 2}	=	(Academic Knowledge 2) + (Error)	(b)
	(Aptitude Test Score 2)	=	(Academic Aptitude 2) + (Error)	(c)
	High School GPA Achievement Test Score Aptitude Test Score Socioeconomic Background	→	College Quality	(3)
Period 3	Academic Aptitude 2 Academic Knowledge 2 Affective Traits 2	→	College GPA	(4)
	Affective Traits 2 College Quality	→	Affective Traits 3	(5)
	{College GPA College Quality}	=	(Academic Knowledge 3) + (Error)	(d)
	{College GPA Achievement Test Scores}	=	(Academic Knowledge 3) + (Error)	(e)
	(Aptitude Test Score 3)	=	(Academic Aptitude 3) + (Error)	(f)
Period 4	Academic Aptitude 3 Academic Knowledge 3 Affective Traits 3 Job Environment	→	Job Performance	(6)

matter. It is possible, nevertheless, to make some inferences about the importance of these underlying variables.

Intelligence or Academic Aptitude.

Let us consider first the possibility that the extent to which one masters academic subject matter is not a determinant of job performance, but the observed relationship between GPA and salary results from the fact that persons who got good grades had higher intelligence or academic aptitude (before they went to college) than those who didn't.[35] The estimates presented in Tables 3 and 4-b suggest that this is not the case. Looking at Table 4-b, for example, we observe that the effect of GPA on the rate of salary increase seems not to depend on SEL. If anything, the estimates suggest a slightly stronger effect in the high SEL group. The difference between the estimated effect of GPA1-2 and GPA4 is .0095 in SEL1-2 and .0084 in SEL5-6. However, in the highest selectivity groups, especially SEL1, there is very little variation in academic aptitude;[36] all persons in these groups have very high aptitudes. We still observe a consistent effect of GPA.

The relationships between the rate of increase figures as shown, however, do not give an accurate picture of the relative importance of GPA by SEL groups. We have assumed that job performance can be measured by monetary reward. Thus, we would like to know the effect of GPA (and

[35]It is, of course, unreasonable to think that intelligence alone determines job performance. Most jobs require mastery of certain skills such as reading and writing. But we are here considering the effects of college education, and are referring to intelligence given that a person obtained a high school degree. Even in this case, some skills (e.g., techniques for engineers) may be necessary; but the mastery of these skills above some minimal level may not be relevant.

[36]Average SAT scores at the best schools are very high and there is very little variation among the scores. See, for example, Astin [1971].

other variables) on lifetime earnings. We find that lifetime earnings not only increase with the rate of increase in salary, but do so at an increasing rate. To demonstrate this, let T be the number of years a person works, k be starting salary, and let LE represent expected lifetime earnings. Then,

$$LE = \int_0^T ke^{rt}dt \ ,$$

$$\frac{d}{dr}LE = \int_0^T kte^{rt}dt \ , \text{ and}$$

$$\frac{d^2}{dr^2}LE = \int_0^T kt^2e^{rt}dt \ .$$

The last term, representing the second derivative of lifetime earnings with respect to r, must be greater than zero, since the function under the integral sign is greater than zero (or equal to at $t = 0$) for all values of t.[37] Then we see that given increases in GPA result in greater marginal increases in lifetime earnings the higher the SEL group, since the higher the SEL group, the higher the rate of increase in salary for any GPA level. It could be that differences in GPA represent relatively larger differences in knowledge in better schools.[38] It is also possible that "smarter" persons can make better use of acquired knowledge on the job.

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[37] Differentiation under the integral sign is permissible in this case. Evaluation of the last integral gives the result,

$$\left[\left(T^2e^{rT}\right)/r\right] - \left[2(rT - 1)e^{rT}/r^3\right] - \left[2/r^3\right] \ .$$

[38] Relation (4) suggests that academic aptitude is one of the determinants of GPA. Controlling for SEL, controls for academic aptitude less well as SEL decreases. To this extent, the observed difference in rates of increase by GPA in poorer schools may be partially the result of differences in aptitude. Then, the coefficients on GPA may be "biased" if GPA is interpreted as measuring academic knowledge.

It has been implicitly assumed that the observed relationship between rates of salary increase and college selectivity is primarily due to the higher average scholastic aptitude of persons from better schools. It is also possible that persons from better schools learned more than those in poorer schools; their accrued academic knowledge was greater. Relations (3) and (d) suggest this possibility.

Affective Traits.

It has also been suggested[39] that observed differences in job performance by GPA level may be due to non-academic traits--i.e., some of the affective traits referred to in (4)--which are possessed to a greater extent by persons who do well in school than by those who do poorly. Although this possibility has been viewed pejoratively by some economists, the fostering of non-cognitive traits which are productive should not necessarily be considered as a negative aspect of education. In addition, learning to learn may be just as important for job productivity as acquired knowledge. This ability is presumably reflected in part by GPA.

An attempt has been made to control for some of these traits in the estimation procedure by incorporating the variables SEC, LEAD, SES, and INT, but this is certainly an incomplete representation. However, it seems reasonable to assume that job productive traits which also influence an individual's performance in college (GPA), would influence to some extent his performance in high school (HSGPA).[40] To this extent, HSGPA would be a reasonable proxy for college GPA. If HSGPA were introduced into the regression equation, the effects of GPA and HSGPA should be confounded, at

[39] See Gintis [1971].

[40] In particular, it would appear to be true of the traits which Gintis [1971] contends are important, namely: subordinacy, discipline, cognitive versus affective modes of response, motivation according to external reward.

least to some degree. When this is done, however, we find that HSGPA is not significant and the estimated effects for GPA are affected only slightly. (See Appendix Table 2.) For example, the difference between the highest and lowest estimated GPA effects is reduced only from .0136 to .0126. At least some reduction might be expected since HSGPA and GPA may both be proxies for academic aptitude (not completely controlled for by SEL) and may also be substitute measures for some kinds of knowledge.

Tables 2 and 5 also suggest that the extent to which an individual masters graduate subjects affects his productivity, even if he has demonstrated the possession of traits associated with high grades, by getting high grades as an undergraduate. The evidence does not support the hypothesis that GPA is serving as a proxy for non-cognitive characteristics. The implication is that the knowledge acquired in school contributes to an individual's productivity.

The emphasis on affective traits has been supported[41] by observing that the coefficient on level of education in a regression model is not reduced substantially when an "ability" measure is added to the regression. The implication is that this coefficient would be reduced much more if measures of relevant affective traits were introduced. This argument not only ignores the effect of occupational entry requirements, but also individual differences in the mastery of academic subject matter. Although the findings of this study do not minimize the importance of non-academic traits, they suggest that affective traits do not dominate academic aptitude and knowledge in their effect on the productivity of these college graduates.

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[41] See Gintis [1971].

Occupational Entry Requirements and College as a Filter.

We can now consider the possibility that the higher educational system selects persons with productive (pre-existing) traits, but doesn't enhance an individual's productive ability. We can rule out consideration of productive traits not associated with academic achievement, on the basis of the observation that persons who do better in school also do better on the job. There seems to be no reason to believe that colleges select persons with productive traits which are not related to academic achievement. For example, traits which may be associated with SES appear to be unimportant when academic achievement is controlled for. And, the argument above suggests that the relationship between academic achievement and job performance is not simply due to non-cognitive traits associated with doing well in school. The evidence suggests that college education is not only a signal of productive ability, but in fact enhances this ability.

Pre-Assignment to Jobs with a Future.

Finally, it might be argued that persons from better schools and with better gra[illegible] re initially assigned to positions with greater possibilities for advancement, relative to their productive abilities, than were persons with poorer grades and from lower quality colleges. The limited evidence available, however, does not lend much support to this possibility. It seems reasonable to assume that positive responses to the questions regarding initial job experience and supervisor tend to reflect a favorable initial position. According to the above hypothesis, a positive relationship between SEL and GPA, and SUP and INT would be expected. But it may be seen from Table 1 that the appropriate correlations are quite small; one in fact is negative.

4. The Probability of Promotion as a Measure of Job Performance: a Markov Scheme

An integral part of the previous discussion is the assumed relationship between salary and job performance (or productivity). There is an implicit assumption that salary is somehow adjusted to match individual performance. But in practice, salaries are normally attached to positions in a fi[illegible]d not to the individuals filling them at any particular time. In many large organizations, each position is assigned a grade level and a "basic salary" or wage is associated with each level. This is sometimes referred to as the "salary structure" of the organization. Normally, the higher the position in the firm hierarchy, the higher the salary. Although an individual's salary is largely determined by the position he holds at any given time, this basic salary may be adjusted for years employed, more or less automatically, or by bonuses. Bonuses are particularly important in higher level jobs. Stock options may also be an important component of total earnings.

This suggests that the rate of upward movement of an individual in the firm hierarchy may be a more direct measure of job performance than is his rate of salary increase. Assuming, of course, that persons who are judged by the firm to be "more capable" are promoted faster. It may also yield quantitatively different results, since persons who are not promoted from one level to the next may still receive increases in salary. Thus, differences in grade levels between persons may suggest greater individual differences than are implied by salary differentials. A comparison of results shown in Table 6, with previous results, lends support to this possibility. It must also be remembered that the increasing importance of bonuses as grade level increases tends to magnify differences

TABLE 6

Percent of Sample in Upper Middle Management* or
Higher Positions by Years Employed and SEL/GPA Group**

	SEL1-2	SEL3-4	SEL5-6	SEL1-2	SEL3-4	SEL5-6
	10 Years or More			12 Years or More		
GPA1-2	55 / n=31	45 / n=82	39 / n=33	67 / n=24	53 / n=62	50 / n=22
GPA3	55 / n=38	28 / n=115	26 / n=58	65 / n=31	34 / n=85	29 / n=41
GPA4	39 / n=23	28 / n=113	12 / n=49	56 / n=16	32 / n=94	19 / n=32
	$x^2 = 34.90$			$x^2 = 33.53$		
	SEL1-2	SEL3-4	SEL5-6	SEL1-2	SEL3-4	SEL5-6
	14 Years or More			16 Years or More		
GPA1-2	72 / n=18	55 / n=55	58 / n=19	92 / n=12	62 / n=42	64 / n=14
GPA3	68 / n=28	41 / n=66	31 / n=32	70 / n=23	47 / n=51	31 / n=29
GPA4	57 / n=14	35 / n=69	21 / n=28	56 / n=9	38 / n=42	21 / n=19
	$x^2 = 27.52$			$x^2 = 28.59$		

*Salary grade 12 or above.

** n is the total number of persons in the group. The x^2 statistic pertains to the null hypothesis that the probability of being in a middle management position or higher is the same for all groups. Note that

$$x^2(.05,\ 8) = 15.507 \quad \text{and} \quad x^2(.01,\ 8) = 20.090\ .$$

in grade level. The following description of individual movement within the firm provides a basis and a further rationale for the use of promotion rate as a measure of relative job performance. Estimates of promotion rates based on individual characteristics are then presented.

Progression in the Firm Hierarchy: a Markov Approach.

Assume that an individual can be described completely by a vector of characteristics X . Assume further that each job or position in the firm is assigned a grade level or rating k $(k = 0, \ldots, K)$, where higher k values correspond to higher level jobs. Consider a group of persons all with the same vector X , who are hired by the firm at some level k . For our purposes, k may be assumed to be level 0 . We do not in fact observe X but only a subset of the elements of X , say x . For purposes of exposition, however, we will assume for the time being that X is observed. This allows emphasis of the likelihood that uncertainty about an individual's progression in the firm results not only from the unobserved elements of X , but also from factors other than individual characteristics. Persons in the group are assigned to jobs at different locations within the firm. Thus, they are working under different supervisors and with groups of co-workers with different characteristics.

Although the persons under consideration are assumed to have exactly the same characteristics, they are not likely to be promoted at the same rate. Each individual will be considered in filling openings in some set of higher level positions. These sets will differ between individuals, primarily because they are working in different locations throughout the firm. Persons working in a particular division, for example, may be considered in filling openings in that division, while persons working

in other divisions may not. The set may vary of course with type and level of the position being filled. In order for an individual to be promoted, an opening must occur and he must be selected from among those considered in filling the position. This is likely to become increasingly important as one moves upward in the firm hierarchy. Promotions at very low levels may be less likely to depend on openings occurring. The first promotion, for example, may be automatic after a certain period of time, if one's performance has been acceptable. Thus, even if all individual characteristics were known, and described by X, it would not be known with certainty whether or not an individual would be promoted during any particular period of time.

It is hypothesized, therefore, that an individual moves from level to level within the firm according to a Markov scheme. The expected movement of an individual selected at random from the group is then described by a transition matrix $P = (p_{ij})$, where p_{ij} is the probability of moving from level i to level j during a given time interval and one of the levels is interpreted to mean leaving the firm. An immediate simplification is to assume that $p_{ij} = 0$ for $j < i$ and for $j > i + 1$.

It may be reasonable to assume that the salaries paid by the firm are competitively determined. In this case, competitive must be interpreted to mean that an individual will enter the firm only if the earnings he expects, if he remains in the firm, are as high as those expected in other firms. Presumably, any differences would reflect non-pecuniary benefits. Actual expected earnings may be determined from promotion probabilities and the firm salary structure.

The firm makes the decision to promote or not to promote an individual. The decision to remain or not remain in the firm is normally made by the individual. We have in mind college graduates holding white-collar

jobs. The two decisions, of course, are interrelated.[42] Persons may leave the firm because their subjective probabilities of promotion (which may differ from the p_{ij}) lead them to believe that they can earn more elsewhere, or for reasons not associated with monetary gain (e.g., to live in a different climate, because of job dissatisfaction not associated with salary, etc.). The two reasons are assumed to yield a probability that an individual at level k , selected at random, will leave the firm during a given time period. As mentioned above, for an individual n to be promoted, a position must be open and n must be selected from all individuals who are considered for the job. The probability of an opening will depend on such factors as the departure of other individuals, the growth of the firm, and the grade structure of the firm. The probability that n is selected will depend on the characteristics of all persons considered in filling the position. It might be assumed that among those considered, selection is made by choosing the individual whose perceived job performance (in his current position) is the highest.[43]

Toward Estimation.

It has been hypothesized above that the progression, within the firm hierarchy, of individuals with like characteristics can be described by a transition matrix P . We would like to obtain estimates of all the elements of P , ultimately for persons with different characteristics.

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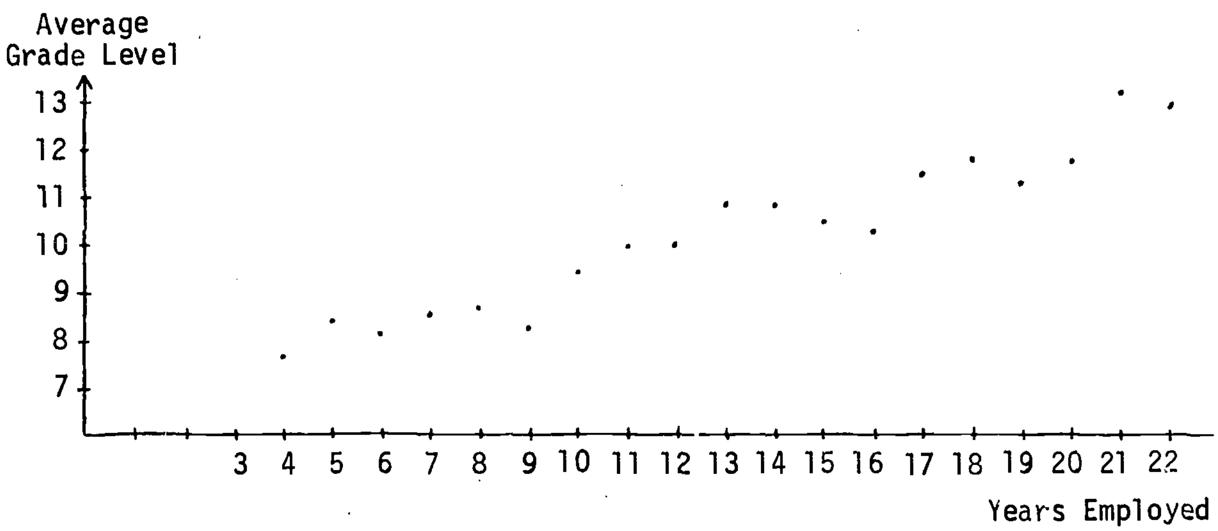
[42]For a model and empirical estimation of the relationship between wages and labor turnover, see Pencavel [1972].

[43]This suggests that the p_{ij} in P may in fact depend on the number of periods spent at level i . It is believed, however, that after a short period of time, more time at the same level will not enhance job performance at that level. Thus the repression of the influence of time spent at a given level is assumed not to represent a gross inaccuracy. Theoretically one could allow for the influence of experience at a given level by expanding the matrix P . For example, one might have entries of the form $p^0_{i,i+1}$, $p^1_{i,i+1}$, where 0 indicates the first period and 1 all periods thereafter.

It is theoretically possible to do this with available data, but highly impractical. Thus, it is necessary to make assumptions which will simplify P . For the time being, we will continue to think of a group of individuals with like characteristics.

Assume that in any time period an individual has a probability p of being promoted from one level to the next, a probability q of remaining at the same level, and a probability w of leaving the firm. In other words, the transition probabilities are assumed to be independent of grade level. Although this may seem unreasonable, the assumption is no stronger than that of a constant rate of increase in salary, which was used above. Or, the assumption of a linear relationship between salary and years employed. A constant rate of salary increase is more consistent with constant promotion probabilities, since salary increases more than linearly with grade level. The assumption may be more plausible when we consider persons employed three years or more, which is the case for the available data. For example, the probability of leaving is usually considered to be greater during the first few years of employment but may not differ greatly by grade level after that. The same may be true of promotion probabilities. Some support for this possibility is found in the adjacent diagram on which average grade level is plotted against years employed.



Assume further that all persons enter the firm at level zero (or that the entry level of each is known). For an individual selected at random, we are interested in the following probability:

$$\Pr\left[\begin{matrix}\text{He is at level } k\\ \text{after } t \text{ years}\end{matrix}\;\middle|\;\begin{matrix}\text{He is still}\\ \text{in the firm}\end{matrix}\right] = \frac{\Pr\left[\begin{matrix}\text{He is at level } k\\ \text{after } t \text{ years}\end{matrix}\right]}{\Pr\left[\begin{matrix}\text{He hasn't left the}\\ \text{firm for } t \text{ years}\end{matrix}\right]}$$

Under the above assumptions, this probability is given by:

$$\frac{\binom{t}{k} p^k q^{t-k}}{(1-w)^t} = \frac{\binom{t}{k} p^k q^{t-k}}{(p+q)^t} = \binom{t}{k}\left(\frac{p}{p+q}\right)^k \left(\frac{q}{p+q}\right)^{t-k} .$$

If we let $c = \binom{t}{k}$, $\hat{p} = p/(p+q)$, and $\hat{q} = q/(p+q)$, we obtain

$$c\, \hat{p}^k (1-\hat{p})^{t-k} .$$

Note the fact that persons who are "pessimistic" about their chances for promotion are more likely to leave the firm does not alter this formula. For N like individuals n , the likelihood function is given by

$$e^L = \prod_{n=1}^{N} c_n \hat{p}^{k_n} (1-\hat{p})^{t_n - k_n} .$$

An Implication for Regression Estimation.

It would be reasonable to estimate grade level by years employed using regression analysis. Under the above assumptions, however, the error term will have a particular variance, even under the assumption that all individual characteristics are known. This will place an upper bound on the fit, or R^2 value, obtained from such a regression. Although in some sense obvious, it seems to have particular importance in this context. In the discussion above, salary was used as a measure of job productivity; but salary is determined largely by grade level.

Therefore, we could not expect to explain all of the variation in salary between individuals by personal characteristics, even if they were all known and precisely measured. In some sense, the model incorporates explicitly the role of "luck" and "turns of fortune" in the determination of individual earnings.

To get some idea of what the limit might be under the above assumptions, a simple example is presented. The expected grade level of an individual n employed t_n years is given by $\hat{p}t_n$ and the variance of grade level by $t_n\hat{p}(1 - \hat{p})$. To estimate k by t using regression analysis, we assume that $k_n = \hat{p}t_n + \varepsilon_n$, where ε_n has mean zero and variance $t_n\hat{p}(1 - \hat{p})$. If both sides of the equation are divided by $\sqrt{t}$, the model becomes homoscedastic. Let $y_n = (k_n/t_n) - \overline{(k_n/t_n)}$ where the bar indicates the sample mean, $z_n = \sqrt{t_n} - \overline{\sqrt{t_n}}$, and $\eta_n = (\varepsilon_n/\sqrt{t_n}) - \overline{(\varepsilon_n/\sqrt{t_n})}$. The R^2 value from the regression is given by

$$R^2 = 1 - \frac{e'e}{y'y} = 1 - \frac{(1/N)e'e}{(1/N)\hat{p}^2\Sigma z_n^2 + (1/N)\Sigma\eta_n^2 + (1/N)2\hat{p}\Sigma z_n\eta_n}$$

where e is the vector of residuals.[44] Taking the probability limit of R^2 as N gets large, we obtain

$$\underset{N \to \infty}{\text{Plim}}\, R^2 = 1 - \frac{\sigma_n^2}{\hat{p}^2 M + \sigma_n^2} = \frac{1}{1 + (1 - \hat{p})/\hat{p}M} ,$$

where $\underset{N \to \infty}{\text{Plim}} \sum_{n=1}^{N} z_n^2/N = M$, the variance of $\sqrt{t}$. If $M = 1$ and $\hat{p} = .4$ (based on probable values from the firm sample used in estimation), the value of this expression would be approximately .40.

[44] Since there is no constant term in the regression, it may be argued that y should not be measured in terms of deviation from the mean. The implications of the example, however, would not be changed by this.

Estimation of Transition Probabilities.

Transition probabilities discussed above were assumed to pertain to individuals with identical characteristics. The firm, of course, hires persons with different characteristics who may be expected to have different transition probabilities. It will be assumed that p, q and w are all functions of χ. A complete description χ of each individual is not available, of course. It may be assumed, however, that information available for each individual represents some of the elements of χ. Say $\chi = (x, x^c)$ where x is available information and x^c is not available. An individual with observed characteristics x is assumed to have some transition probabilities $p(x), q(x), w(x)$. Since only x is observed, the uncertainty about his progression in the firm results not only from factors not represented by χ, but also from unobserved personal characteristics x^c. It is assumed that $p(x)$ represents the mean promotion probability for all individuals $\chi = (x, x^c)$, and similarly for $q(x)$ and $w(x)$. If it should be found that $p(x_n) = p(x)$ for all n, we would conclude that the elements of χ which have been isolated do not affect job productivity.

To estimate transition probabilities from the available sample, the following maximum likelihood procedure has been used.[45] Consider N

[45] Estimates could of course be obtained by regression analysis using the model

$$k_n = p_n(x_n) \cdot t_n + \varepsilon_n ,$$

where say $p_n(x_n) = \beta' x_n$ with β a vector of parameters. This is referred to as a linear probability model. In this model, however, the variance of ε_n given by $t_n p_n(x_n)[1 - p_n(x_n)]$, depends on the expected value of k_n. A simple correction for heteroscedasticity is not possible in this case. Two stage procedures estimating $p_n(x_n)$ in the first stage and using weighted least squares in the second have been suggested. (See for example Goldberger [1964].) Johnson and Leone [1964] suggest another method of finding a transformation which yields approximate homogeneity. A further difficulty is that the estimated probabilities are not constrained to lie within the [0,1] interval.

individuals n, with information x_n on each. Analogous to the above discussion, for any n,

$$\Pr\left[\begin{matrix}n \text{ is at level } k_n \\ \text{after } t_n \text{ years}\end{matrix} \middle| \begin{matrix}n \text{ is still} \\ \text{in the firm}\end{matrix}\right] = \binom{t_n}{k_n}\left(\frac{p_n}{p_n + q_n}\right)^{k_n}\left(\frac{q_n}{p_n + q_n}\right)^{t_n - k_n} .$$

The likelihood function for N persons is given by

$$e^{L} = \sum_{n=1}^{N} c_n p_n^{k_n} (1 - p_n)^{t_n - k_n} ,$$

where p_n represents $p_n/(p_n + q_n)$ and $c_n = \binom{t_n}{k_n}$, and the log-likelihood function by,

$$L = \sum_{n=1}^{N} \{\ell n\, c_n + k_n\, \ell n\, p_n + (t_n - k_n)\, \ell n\, (1 - p_n)\} .$$

It is assumed that the relationship between x_n and p_n is described by a logistic probability function[46] of the form,

$$p_n = \frac{1}{1 + e^{-\theta' x_n}} ;$$

where θ is a vector of parameters. Then

$$\ell n[p_n/(1 - p_n)] = \theta' x_n ,$$

and

$$L = \sum_{n=1}^{N} \ell n\, c_n + \sum_{n=1}^{N} (k_n - t_n)(\theta' x_n) - \sum_{n=1}^{N} t_n \ell n\, (1 + e^{-\theta' x_n}) .$$

To find the vector θ which maximizes[47] this function, a modification

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[46] See for example Cox [1970].

[47] The first order conditions for a maximum require that the equations given by the vector of partial derivatives,

$$\frac{\partial L}{\partial \theta} = \sum_{n=1}^{N} k_n x_n - \sum_{n=1}^{N} t_n \left|\frac{1}{1 + e^{-\theta' x_n}}\right| x_n = \sum_{n=1}^{N} (k_n - t_n p_n) x_n ,$$

of a program developed by McFadden [1968], has been used.

The variables included in the vectors x_n are the same as those used in the regression analysis. But in this case, variables which pertained to starting salary are not used since they have been used also to determine starting grade level. Although the current (1968) grade level of persons in the sample is known, the level at which they entered the firm is not. It was necessary to estimate initial grade level in order to obtain estimates of the number of promotions received.[48]

Results.

Maximum likelihood estimates of elements of the vector θ are listed in Tables 7 and 8. The estimates in Table 7 were obtained using 6 SEL groups and 4 GPA groups, and those in Table 8, using 3 SEL and 3 GPA groups. The implied probabilities of promotion for persons with a B.A. degree, by SEL-GPA group, are also shown. For comparison, estimates

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be equal to zero. It can be seen that the second order conditions for a maximum are satisfied by noting that the Hessian matrix is given by

$$\frac{\partial L}{\partial\theta\partial\theta'} = \sum_{n=1}^{N} t_n x_n x_n' \frac{e^{-\theta' x_n}}{(1 + e^{-\theta' x_n})^2} = - \sum_{n=1}^{N} t_n p_n (1 - p_n) x_n x_n' .$$

The last term is the negative of the weighted sum of positive definite matrices (where the weights are positive), which is negative definite. This insures that L is strictly concave and that the maximum is unique.

[48] The error involved is assumed to be small, however, since most persons with a B.A. degree and no experience would have entered at one of two levels, according to firm officials. To estimate entering grade level, current grade was substituted for log of salary in Model I and estimated coefficients obtained. The estimated constant and coefficients on BA, ENG, BUS, and EXP were used in estimating starting grade levels. The estimated levels are consistent with observed data points--between 3 and 22 years--assuming constant promotion probabilities. If promotions are more likely during the first few years than in later years, as seems likely, the estimates tend to overstate actual starting levels. The extent of the overstatement, however, is unlikely to vary greatly between groups of individuals. Thus any bias in relative differences between estimates of promotion probabilities should be small.

TABLE 7

Logistic Distribution Parameter Estimates

Variable	Estimated Coefficient	Standard Error
Constant	-.3852	(.2497)
SEL1	.5056	(.1379)
SEL2	.0098	(.0687)
SEL3	.0407	(.0727)
SEL4	-.0865	(.0486)
SEL5	-.1583	(.0635)
SEL6	-.3113	
GPA1	.3209	(.0786)
GPA2	.0468	(.0475)
GPA3	-.1074	(.0371)
GPA4	-.2603	
MA1	.4101	(.1600)
MA2	-.0222	(.0831)
MA3	-.0506	(.0882)
MA0	-.3373	
SEC	-.1350	(.0237)
SES	.0158	(.0156)
LEAD	.0914	(.0139)
INT	.0561	(.0127)
SUP	.0574	(.0187)

Probability of Promotion for Persons with a BA Degree*

	SEL1	SEL2	SEL3	SEL4	SEL5	SEL6
GPA1	.526	.403	.411	.380	.364	.329
GPA2	.458	.339	.346	.318	.303	.271
GPA3	.420	.306	.313	.287	.271	.242
GPA4	.383	.274	.281	.256	.242	.217

*Assuming the mean value (zero) for other variables. The entry in the i^{th} column and j^{th} row is equal to: $1/(1 + e^{-b})$; where b is given by, constant + MA0 + SEL(i) + GPA(j).

TABLE 8

Logistic Distribution Parameter Estimates,
Three SEL and Three GPA Groups

Variable	Estimated Coefficient	Standard Error
Constant	-.5484	(.2348)
SEL1-2 SEL3-4 SEL5-6	.1243 .0133 -.1376	(.0438) (.2487)
GPA1-2 GPA3 GPA4	.1903 -.0208 -.1695	(.0327) (.0645)
MA1 MA2 MA3 MA0	.4103 -.0313 -.0409 -.3381	(.1594) (.0828) (.0879)
SEC SES LEAD INT SUP	-.1356 .0207 .0947 .0555 .0597	(.0237) (.0155) (.0139) (.0127) (.0181)

Probability of Promotion for Persons with a BA Degree*

	SEL1-2	SEL3-4	SEL5-6
GPA1-2	.361	.336	.303
GPA3	.314	.290	.260
GPA4	.282	.260	.233

*Assuming the mean value (zero) for other variables. The entry in the i^{th} column and j^{th} row is equal to: $1/(1 + e^{-b})$, where b is given by, constant + MA0 + SEL(i) + GPA(j) .

based on a linear probability model[49] were obtained and are listed in Appendix Tables 4 and 5.

As expected, the parameter estimates imply quite large differences in promotion probabilities between SEL-GPA groups. Again, all of the non-academic variables except SES are significant. A large effect of doing well in graduate school is also observed; but the promotion probabilities suggest (the relevant differences are not significant) a somewhat larger effect of obtaining an MA degree, even with low class rank, than was implied by the rate of salary increase figures. This may mean that MA holders are elevated to supervisory positions more often than BA holders, but differences in grade level do not always imply salary differences. Probabilities of promotion for BA (MA0) and MA holders, calculated from estimates in Table 7, assuming other variables are at their means, are as follows: MA0, .327; MA3, .393; MA2, .398; and MA1, .506. Finally, because of the logistic transformation assumed in the estimated model, the calculated promotion probabilities as shown imply that the effect of GPA increases with SEL, and the effect of SEL with GPA.

The assumption of promotion probabilities allows a direct demonstration of the distribution of individuals by grade level after a given number of years in the firm. Table 9 shows the probabilities of obtaining k promotions if an individual with a B.A. degree stays in the firm for 10 years $(k = 0, \ldots, 10)$, by SEL-GPA group. This is another way of emphasizing the relatively large dispersion in grade level (or earnings)

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[49] $E(k_n) = p_n t$, where $p_n = \beta' x_n$ and β is a vector of parameters. (See footnote 45.) The estimates were obtained by least squares regression. In this case, the two methods yield very similar estimates. The values of p calculated from the linear probability model, however, tend to be slightly higher than those from the logistic model. This appears to be due to the way in which entering grade level was estimated.

TABLE 9

Estimates of the Probability of Obtaining k Promotions in Ten Years, by Selected SEL-GPA Group*

Group	Estimated Value of p	Promotions (k)										
		0	1	2	3	4	5	6	7	8	9	10
SEL1/GPA1	.53	.00	.01	.03	.09	.18	.24	.23	.15	.06	.02	.00
SEL6/GPA4	.22	.08	.24	.30	.22	.11	.04	.01	.00	.00	.00	.00
SEL1-2/GPA1-2	.36	.01	.06	.16	.25	.25	.16	.08	.02	.01	.00	.00
SEL5-6/GPA4	.23	.07	.22	.29	.23	.12	.04	.01	.00	.00	.00	.00

*For persons with a BA degree only and assuming other variables to be equal to their mean values. The implied distribution would probably be shifted slightly to the right if allowance were made for larger promotion probabilities during the first three years of employment than for later years.

that might be expected for persons with similar academic backgrounds. Other variables are again assumed to be equal to their mean values.

5. Conclusions and Comparison with Other Studies

The hypothesis of no relationship between academic achievement and job performance must be rejected for this sample of college graduates. The differences in estimated rates of increase in salary (and promotion probabilities) by college selectivity and college grade point average are substantial. These findings are consistent with those of Weisbrod and Karpoff [1968] who related earnings to college class rank and college quality using a sample of employees of the American Telephone and Telegraph Company.[50] Although they were unable to control for other individual characteristics, their calculated salary index increases with both class rank and college quality.[51] If persons with the same level of education can be distinguished by the "quality" of their degrees, then surely there would be an even greater difference in job performance between persons with different levels of education; e.g., high school versus college.

The measures used in selection and certification are not only related to productive traits, but college education seems clearly to have enhanced the productive capabilities of these persons.

It has also been found that other individual characteristics seem just as important as academic attributes in the determination of job productivity. Although not affording a direct comparison, the conclusions

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[50] The data used represented within-group means, rather than individual observations, where the groups were defined by class rank, college quality, and years employed. College quality was defined by the "subjective assessment" of company personnel officers.

[51] A similar pattern was obtained in this study using the "salary index" but the results have not been shown here.

reached by the industrial psychologist Ghiselli [1969] using an entirely different approach tend to parallel the findings here, especially with respect to the non-academic variables. From his involvement in several studies of the psychological traits of managers and line workers, he concluded that the following traits were of particular importance to managerial success: intelligence, supervisory ability, initiative, self-assurance, and perceived occupational level. In drawing comparisons with the findings of this study, it might be assumed that intelligence is loosely captured (along with knowledge) by SEL and GPA and that supervisory ability is represented by LEAD. Initiative, which he described as a "certain independence and inventiveness," has been assumed to be partially reflected in INT. Self-assurance, which he assumed to be possessed by an individual who perceives himself as being effective in dealing with problems which confront him--who is "self-confident," is likely to be inversely related to SEC.[52] Finally, perceived occupational level, which may be a "level of aspiration," would presumably be affected by SES, although SES was not significant in this study after controlling for other variables.

Finally, the description of progression in the firm hierarchy based on a Markov model suggests a significant limitation on the proportion of variation in earnings (or grade level) which could possibly be explained by a complete and accurate description of personal attributes.

Some indication of the reasons for the apparent discrepancy between the conclusion of Berg [1970] and those suggested by this study is provided by Wolfle and Smith [1956]. They found that high school class rank--

[52] He in fact says that: "Self-realization and autonomy universally are more important to managers than prestige, social satisfaction, and even security."

which might be taken as a measure of academic ability or achievement--had little to do with earnings 20 years later for persons who entered technical schools, had some college, or had no post high school education; but was strongly related to earnings for those with one or more college degrees. Berg's results pertained largely to jobs not normally held by college graduates.

In conclusion, measures of academic achievement and ability used in the selection and certification process in higher education are not only related to the productivity of college graduates in this sample, but the results suggest that college education contributed to their productive ability. These findings lend support to the practice of selecting students on the basis of academic measures. But non-academic attributes, largely independent of academic characteristics, have also been shown to affect productivity. The two groups seem to be of approximately equal importance. In light of the use of the college degree as an occupational screening device, this suggests a second look at the practice of selecting persons for higher education solely or largely on the basis of academic aptitude or achievement. If persons were selected for higher education on the basis of their potential productivity in a chosen occupation, rather than their potential as future students, consideration of non-academic as well as academic attributes would be necessary.

APPENDIX

APPENDIX TABLE 1

Selected Biographical Questions

I. Socioeconomic Background

* 1. How many books were in your home during your youth?
(1) fewer than five books
:
(5) a large library

* 2. The occupation which your father (or guardian) followed for most of his life may best be described as:
(1) unskilled or semi-skilled work
:
(8) business executive

* 3. What was the highest educational level your mother (or guardian) achieved?
(1) high school graduate or less
:
(5) one or more graduate degrees

* 4. What was the highest educational level your father (or guardian) achieved?
(1) high school graduate or less
:
(5) one or more graduate degrees

II. Leadership and Organizational Ability

* 1. By the time you had graduated from high school, how many of the following had you been: captain of an athletic team, editor of the school paper or yearbook, president of a school club, president of your class or the student council, chairman of an important student committee?
(1) none
:
(6) five

* 2. Choose the alternative which best describes your ability as an organizer or your influence upon groups of people during your high school and college years.
(1) you never considered yourself as an organizer or a leader of groups
:
(4) you were quite active in student government and campus organizations, or community organizations. You were the mover in setting up goals or projects and seeing that they reached completion.

* 3. To how many offices in student organizations, such as student council, interfraternity council, etc., were you elected in college?
(1) none
:
(5) seven or more

* 4. How many of the following did you hold at some time while at college: captain of a varsity athletic team, chairman of an important student committee, editor of the school paper or yearbook, leading actor in a class play, president of an honorary scholastic or leadership organization, president of your class or the student council, president of your social fraternity?
(1) none
:
(5) five or more

5. During your high school years, how many of the following high school organizations were you a member of: athletic team, social club or fraternity, school group (debating team, political science club, etc.), school musical organization (band, orchestra, chorus, etc.), honor society?
(1) none
:
(5) five

III. <u>Initial Experience in the Firm</u> (Unless otherwise indicated, the following questions come under the general heading: To what extent did the following conditions exist in the jobs you held during your first two years with the company?)

* 1. Chance to do imaginative thinking.
(1) very little (or not at all),..., (5) very much

* 2. Opportunity to communicate with higher management.
(1) very little (or not at all),..., (5) very much

* 3. Could use initiative.
(1) very little (or not at all),..., (5) very much

* 4. Attention paid to your suggestions.
(1) very little (or not at all),..., (5) very much

* 5. Opportunity to exercise your leadership skills.
(1) very little (or not at all),..., (5) very much

* 6. To what extent do you feel that your first assignments made use of your abilities?
(1) jobs were much below your abilities
:
(4) really pushed most of the time

* 7. Opportunity to make own decisions.
(1) very little (or not at all),..., (5) very much

* 8. How much responsibility were you given in your first job with the company?
(1) very little (or not at all),..., (5) very much

9. Which one of the following was most characteristic of the jobs you held during your first two years at the firm?
   (1) was told to follow a set procedure
   (2) was given some supervision with the details up to me
   (3) was pretty much on my own

10. How many different jobs (rotational moves) did you have during your first two years with the company?
    (1) none or one,..., (5) five or more

11. Understanding of work problems by management.
    (1) very little (or not at all),..., (5) very much

12. Encouraged to put forth effort to better yourself.
    (1) very little (or not at all),..., (5) very much

IV. Initial Supervisor (Unless otherwise indicated, the following questions come under the general heading: To what extent were the following descriptive of your first supervisor at the company?)

* 1. Advanced subordinates who showed ability.
   (1) very little (or not at all),..., (5) very much

* 2. Included subordinates in decision making.
   (1) very little (or not at all),..., (5) very much

* 3. Was receptive to new ideas.
   (1) very little (or not at all),..., (5) very much

4. What kind of supervision did you receive on your first assignment?
   (1) close supervision--concerned with details
   (2) consistent and adequate supervision--concerned with important elements
   (3) only general supervision which allowed considerable expression of my ideas
   (4) received practically no supervision

V. Goals When Joined Firm (Unless otherwise indicated, the following questions come under the general heading: How important were the following goals to you when you started work at the company?)

1. Job security.
   (1) very little (or not at all),..., (5) very much

2. What was your knowledge of your career goals when you started work at the company?
   (1) had no specific career goals in mind
   :
   (4) sure of career goals

3. Opportunity for advancement.
   (1) very little (or not at all),..., (5) very much

4. Financial reward.
   (1) very little (or not at all),..., (5) very much

*Used in constructing--by principle components--variables used in regression analysis.

APPENDIX TABLE 2

Parameter Estimates with HSGPA Included as a Right-Hand-Variable, Total Sample

Variable	Estimated Coefficient	Standard Error	F-Statistic
Constant	6.60326		
BA BA'	.02626 -.02626	(.01079) (.01079)	F = 5.923
ENG LIB BUS	.03620 -.01251 -.02369	(.00778) (.00957)	F = 13.363
EXP	.01658	(.00315)	
AV	.04481	(.00171)	
SEL1 SEL2 SEL3 SEL4 SEL5 SEL6	.01065 .00197 .00121 -.00136 -.00404 -.00793	(.00310) (.00121) (.00148) (.00091) (.00117)	F = 9.376
GPA1 GPA2 GPA3 GPA4	.00734 .00020 -.00223 -.00531	(.00134) (.00088) (.00075)	F = 15.771
HSGPA1 HSGPA2 HSGPA3 HSGPA4	.00134 .00084 -.00101 -.00117	(.00095) (.00069) (.00075)	F = 1.614
MA1 MA2 MA3 MA0	.01235 -.00025 -.00487 -.00723	(.00310) (.00182) (.00193)	F = 11.367
SEC SES LEAD INT SUP	-.00307 .00030 .00214 .00071 .00140	(.00045) (.00031) (.00028) (.00025) (.00035)	F = 40.615

R^2 = .69186

N = 976

APPENDIX TABLE 3

Mean of Salary "Index" by Response to Selected Biographical Questions*

Question	R^2	F-Statistic**	Response†						
			1	2	3	4	5	6	7
Socioeconomic Background									
Books in Home	.023	6.04	-6.44	-3.89	-1.04	3.94	8.09		
Father's Occupation	.021	2.75	-5.12	-4.34	-2.30	1.18	1.31	1.81	5.54††
Education of Mother	.017	3.59	-7.12	-1.55	4.59	8.12	0.22	2.03	
Education of Father	.010	1.77	-2.72	-0.81	-0.22	1.82	11.38	6.25	
Academic Achievement									
College Selectivity	.107	15.29	-10.20	-6.34	-0.24	5.73	11.35	31.71	
Undergraduate GPA	.075	16.59	-5.26	-6.34	-0.48	5.99	18.47		
High School GPA	.069	15.13	-1.78	-8.93	-3.40	2.48	10.98		
UG Grades in Math, Physics, Chemistry, or Engineering	.055	14.82	-4.78	-3.88	2.08	15.66			
College Honor Societies Member of	.048	12.76	-2.79	1.96	12.05	24.15			
How BA Awarded Re Honors	.047	10.05	-2.44	13.20	4.42	24.25			
UG Grades in English or Journalism	.034	8.90	-6.15	-3.12	1.25	9.35			
Awards for Scholastic Achievement in High School	.033	8.74	-2.58	-2.40	4.42	7.77	11.66		
Achievement in Creative or Journalistic Writing	.024	8.21	-1.85	5.87	16.22	9.25			
UG Grades in Business	.021	5.38	-9.49	-2.87	-1.97	5.96			
Leadership & Organizational Ability									
Leadership Positions Held in High School	.022	3.81	-2.57	-0.93	5.58	7.55	3.23	-0.35	
Ability as an Organizer	.058	15.85	-4.91	-3.02	6.78	11.46			
College Offices Elected to	.043	11.59	-3.26	3.28	5.84	12.31	26.15		
College Organizations Headed	.038	13.46	-2.67	4.73	11.02	12.42			
Organizations Member of in High School	.016	2.70	-5.24	-1.85	-0.81	4.80	1.23	-2.51	

APPENDIX TABLE 3 (continued)

Question	R^2	F-Statistic**	Response† 1	2	3	4	5	6	7
Initial Experience in Firm									
Chance to Do Imaginative Thinking	.089	24.34	-11.02	-6.51	-0.14	7.59	12.55		
Opportunity to Communicate with Higher Management	.067	18.33	-7.64	-4.00	-2.52	8.72	10.38		
Could Use Initiative	.059	16.12	-14.27	-8.74	-3.08	2.78	7.87		
Attention Paid to your Suggestions	.049	13.19	-9.23	-9.15	-2.23	4.61	8.60		
Opportunity to Use Leadership Skills	.045	12.01	-6.17	-1.42	0.22	7.10	11.67		
Extent Assignments Made Use of Abilities	.039	10.23	-7.68	-2.18	5.87	2.05	6.24		
Opportunity to Make Own Decisions	.036	9.51	-7.99	-6.37	-0.06	5.43	6.01		
Responsibility on First Job	.032	8.57	-4.26	-3.63	-2.00	4.10	10.14		
General Guideline Instructions (as Opposed to Following Set Procedure)	.056	20.23	-10.90	1.08	7.90				
How Many Different Jobs	.041	8.74	-9.28	-7.26	-1.25	2.56	6.85		
Understanding of Work Problems by Management	.027	6.99	-13.59	-3.95	0.16	1.67	7.00		
Encouraged to Put Forth Effort to Better Self	.022	5.62	-5.03	-5.14	-0.96	2.75	5.19		
Initial Supervisor									
Advanced Subordinates Who Showed Ability	.046	9.74	-9.28	-5.70	-1.02	4.43	7.33		
Included Subordinates in Decision-Making	.038	8.00	-6.76	-4.77	0.35	6.36	4.75		
Receptive to New Ideas	.035	7.48	-5.14	-7.46	-1.06	3.21	8.12		
Type of Supervision (Detailed-General-None)	.017	4.37	-5.85	-0.54	3.26	-1.85			
Goals When Joined Firm									
Job Security	.092	25.88	13.12	3.05	-1.50	-8.93	-12.72		
Knowledge of Career Goals	.024	6.39	-4.49	-2.72	2.69	7.07			

APPENDIX TABLE 3 (continued)

Question	R^2	F-Statistic**	Response† 1	2	3	4	5	6	7
Opportunity for Advancement	.015	3.86	-10.26	-16.69	-7.74	-0.87	1.73		
Financial Reward	.002	0.58	0.84	-0.72	-1.12	-0.42	1.88		
Place of Work Within Firm Structure									
Time at Central Staff	.086	19.17	-3.84	10.61	18.58	13.79	9.63		
Time at Plant, Depot, or District Sales Office	.070	15.28	4.62	7.58	0.11	0.23	-9.21		
Time at Division Staff	.067	14.75	-6.68	1.83	11.17	5.28	2.92		
Other									
Member of Fraternity (No-Yes)	.025	26.52	-2.26	6.55					
Time Decided on UG Major	.023	4.86	1.01	6.11	-1.38	-1.79	-4.83		
For Those Who Obtained MA after Joining Firm									
Rank in Graduate Class	.107	3.80	9.64	5.39	13.55	31.54			
Reason Went to Graduate School:									
Learn for Sake of Learning	.049	1.31	18.56	13.70	13.49	7.07	2.40		
Increase Salary Potential	.045	1.50	---	5.43	20.11	9.30	13.01		
Parental or Social Pressure	.027	1.16	13.48	11.19	7.70	---			
Apply Knowledge to Occupation	.007	0.23	---	---	10.88	11.71	14.18		

*The results were obtained by an analysis of variance model of the form: $e_{ij} = \beta_i + \varepsilon_{ij}$, where e_{ij} is the salary index number of the j^{th} individual giving the i^{th} response. The responses are ordered from "low" to "high," where the interpretation of "low" and "high" may vary from question to question.

** $F_{.01}(V,\infty)$ is 3.78 for V = 3, 3.32 for V = 4, 3.02 for V = 5, 2.80 for V = 6.

$F_{.05}(V,\infty)$ is 2.60 for V = 3, 2.37 for V = 4, 2.21 for V = 5, 2.10 for V = 6.

APPENDIX TABLE 3 (continued)

†The mean for persons not answering a given question is not shown here.

††This is the mean for the last three responses.

APPENDIX TABLE 4

Linear Probability Parameter Estimates

Variable	Estimated Coefficient	Standard Error
Constant	.3576	(.0175)
SEL1	.1112	(.0305)
SEL2	.0087	(.0118)
SEL3	.0038	(.0149)
SEL4	-.0182	(.0091)
SEL5	-.0370	(.0115)
SEL6	-.0696	
GPA1	.0717	(.0130)
GPA2	.0050	(.0086)
GPA3	-.0230	(.0073)
GPA4	-.0536	
MA1	.1191	(.0331)
MA2	-.0127	(.0185)
MA3	-.0350	(.0195)
MA0	-.0713	
SEC	-.0224	(.0045)
SES	.0013	(.0031)
LEAD	.0185	(.0027)
INT	.0084	(.0025)
SUP	.0109	(.0035)

Probability of Promotion for Persons with BA Degree*

	SEL1	SEL2	SEL3	SEL4	SEL5	SEL6
GPA1	.4692	.3667	.3618	.3398	.3210	.2884
GPA2	.4025	.3000	.2951	.2731	.2534	.2217
GPA3	.3745	.2720	.2671	.2451	.2263	.1937
GPA4	.3439	.2414	.2365	.2145	.1957	.1631

*Assuming the mean value (zero) for other variables. The entry in the i^{th} column and j^{th} row is equal to: Constant + MA0 + SEL(i) + GPA(j) .

APPENDIX TABLE 5

Linear Probability Parameter Estimates,

Three SEL and Three GPA Groups

Variable	Estimated Coefficient	Standard Error
Constant	.3221	(.0164)
SEL1-2	.0325	(.0082)
SEL3-4	.0011	(.0060)
SEL5-6	-.0336	
GPA1-2	.0377	(.0066)
GPA3	-.0040	(.0059)
GPA4	-.0337	
MA1	.1185	(.0334)
MA2	-.0142	(.0187)
MA3	-.0333	(.0196)
MA0	-.0710	
SEC	-.0220	(.0046)
SES	.0025	(.0031)
LEAD	.0193	(.0027)
INT	.0083	(.0025)
SUP	.0116	(.0036)

Probability of Promotion for Persons with a BA Degree*

	SEL1-2	SEL3-4	SEL5-6
GPA1-2	.3213	.2899	.2552
GPA3	.2796	.2482	.2471
GPA4	.2499	.2185	.1838

*Assuming the mean value (zero) forother variables. The entry in the i^{th} column and j^{th} row is equal to: Constant + MA0 + SEL(i) + GPA(j) .

APPENDIX I

SEL and GPA versus Starting Salary

The estimation of starting salary is complicated by the absence of observations pertaining to persons employed fewer than three years. Thus the estimate of starting salary is actually the backward projection of a regression line (or surface) based on data points corresponding to years employed of three or more.

A straightforward method for testing for differences in starting salary by SEL and GPA group is to alter Model I in the following way:

$$s = e^{a} e^{rt} e^{\varepsilon}$$

$$a = a_o + a_i + b_j + f_k + g_\ell + dx_o ,$$

$$r = r_o + \alpha_i + B_j + \gamma_k + \Sigma_{\ell=1}^{5} \delta_\ell x_\ell , \text{ where}$$

f is the effect on starting salary of being in the k^{th} selectivity group and g_ℓ the effect of being in the ℓ^{th} GPA group. The other symbols are defined as above. The appropriate restrictions, as in Model I, must also be added. Then test the null hypothesis $H_o : f_i = g_\ell = 0$ for all k and ℓ . Upon carrying out this test it is found that the null hypothesis cannot be rejected at reasonable levels of significance. However, if instead of the above hypothesis, the hypothesis $H_o : \alpha_i = B_j = 0$ for all i and j is tested, it is not rejected either. In other words, these effects cannot be distinguished in this model. That is, if the rate of increase is not allowed to vary by SEL and GPA groups, then a good substitute when fitting the data points is to allow the whole curve relating the log of salary to years employed to shift upward or downward by a given amount for different SEL and GPA groups. Therefore, different approaches

were tried.

The first was to estimate rates of salary increase and initial salary for different SEL/GPA groups separately. Model I was estimated for 9 SEL/GPA groups. The estimates of starting salary and rates of increase for persons with a B.A. degree only for each of these groups are shown in Appendix Table 6. The six SEL and four GPA groups were combined as indicated. The estimates of rate of salary increase may be compared with those in Table 4-b, since the groupings are the same. The general outline of the two sets of estimates is quite similar. The difference between the highest and lowest rates is .018 in the first table and .017 in the second. But the relationship between the estimates is less consistent in Appendix Table 6.

The estimates of starting salary tend to be somewhat higher on the average with increasing GPA and SEL. But the estimates also exhibit certain relationships which should probably be rejected *a priori*. It seems unreasonable to assume that starting salaries for GPA3 could be higher than those in GPA1-2 as is suggested by these estimates for both SEL1-2 and SEL5-6. In fact, in SEL5-6 the estimate for GPA4 is higher than for GPA1-2. Within GPA3, persons from SEL5-6 schools have a higher estimated starting salary than those from SEL3-4 schools. Although it might be reasonable to pay higher starting salaries to persons from better schools and with better grades, the reverse certainly seems unreasonable.

Outlying observations, particularly near the extremes of the range of years employed (3-22), tend to have an exaggerated effect on the estimate of starting salary, as well as the rate of salary increase, when there are no observations for starting salary. This is especially

APPENDIX TABLE 6

Estimates of Starting Salary and Rates of Increase in Salary by SEL/GPA Group

Model: $s = e^a e^{rt} e^{\varepsilon}$

$$a = a_o + a_i + b_j + dx_o$$

$$r = r_o + \gamma_k + \Sigma_{\ell=1}^{5} \delta_\ell x_\ell$$

$$\Sigma_i a_i = \Sigma_j b_j = \Sigma_k \gamma_k = 0$$

	Estimates of Initial Salary, $\hat{a}_o$ *		
	SEL 1-2	SEL 3-4	SEL 5-6
GPA 1-2	6.779 (n= 44)	6.740 (n=129)	6.676 (n= 75)
GPA 3	6.872 (n= 49)	6.690 (n=202)	6.737 (n=113)
GPA 4	6.726 (n= 38)	6.699 (n=189)	6.693 (n=137)
	Estimates of Rate of Salary Increase, $\hat{r}_o + \hat{\gamma}_k$ **		
	SEL 1-2	SEL 3-4	SEL 5-6
GPA 1-2	.0450 (.0094)	.0343 (.0037)	.0351 (.0072)
GPA 3	.0307 (.0082)	.0346 (.0023)	.0322 (.0064)
GPA 4	.0337 (.0077)	.0310 (.0035)	.0282 (.0051)

*The number of observations in each category is n .

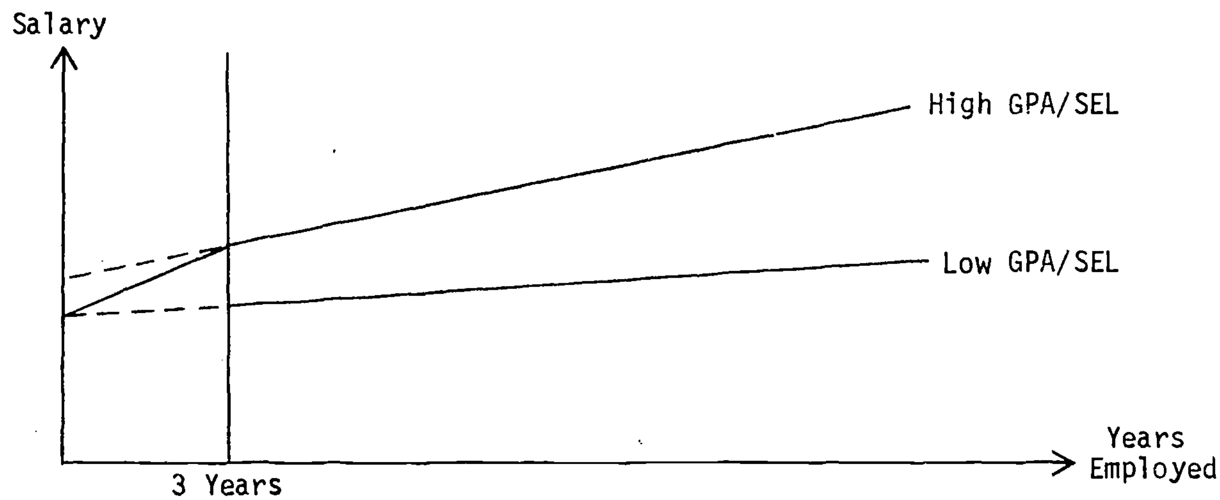
**The standard errors shown in parentheses are for $\hat{\gamma}_k$ only.

true in categories with a small number of observations. Thus a few outlying observations may produce somewhat perverse results. This in fact seems to be the case here. Plots of salary versus years employed were made for each of the nine SEL/GPA groups. In each of the groups SEL1-2/GPA1-2, SEL1-2/GPA3, SEL3-4/GPA1-2, and SEL5-6/GPA3, there were one or two divergent observations representing high salaries and few years employed.

It seems reasonable in this case to constrain the model in such a way as to disallow results implying "unreasonable" inconsistencies such as those discussed above. The resulting estimates will be more robust with respect to extreme observations. One way of doing this is to constrain the model as is done in Model I.

Finally, if we ignore the estimate for SEL1-2/GPA3, the difference in starting salary between the highest SEL/GPA group and the lowest suggested by these estimates is less than 10 percent.

A different line of argument suggests that initial salary will in general be overestimated by the above procedure and that the extent of the error is likely to be greater for persons in high GPA/SEL groups than in lower groups, if indeed persons in higher groups are more capable. Capable persons may tend to be promoted quite rapidly during their first years in the firm since promotions at low levels may be largely dependent on the discretion of one's immediate supervisor. One need not wait for openings to occur, as is likely to be the case at higher levels. Once the low level grades are passed, promotion may depend on openings occurring. Assume that this rapid advancement at first as compared with a slower rate of advancement later on is more pronounced for persons in high SEL/GPA groups than lower groups. Say the typical pattern for extreme groups looks as follows:



In this case, fitting observations pertaining to persons employed 3 or more years would tend to overstate initial salary for the high group more than for the low one. It appears that this effect may be present to some extent at least.

A test for the equality of constant terms in the above regressions by SEL/GPA groups was not made because of the large matrix required. Such a test was made for a simplified model, however, which excludes all of the right-hand variables except years employed. The model is

$$s_{ij} = e^{a_{ij}} e^{b_{ij}} e^{\varepsilon_{ij}} \text{ , where}$$

$e^{a_{ij}}$ is the starting salary of persons in the ij^{th} SEL/GPA group and b_{ij} the rate of salary increase for the ij^{th} group. Three SEL and three GPA groups were used as above. The null hypothesis that all the a_{ij} are equal is not rejected at the .05 level of significance. (The F-statistic was 1.16812). It may be noted that this test is stacked in favor of rejecting the null hypothesis since persons from better schools are more likely to be engineers or scientists and would tend to have higher starting salaries. Thus if the other variables were included, we

would expect to obtain a lower F-statistic.

Finally, in order to get some idea of the size of the bias in the rate of increase which might result from constraining the constant terms to be the same for all groups when in fact they are not the same, we consider a simple example. Assume that there are two groups and for each group we have a single observation at each of the years through n . Assume that the observations are generated by the following model:

$$\ell n\ s = \alpha_1 D_1 + \alpha_2 D_2 + \beta_1 (D_1 t) + \beta_2 (D_2 t) + \varepsilon\ , \text{ where}$$

$$D_i = \begin{cases} 1 \text{ for persons in the } i^{th} \text{ group, and} \\ 0 \text{ otherwise} \end{cases},$$

s = salary

t = years employed.

The estimated model, however, is of the form

$$\ell n\ s = \alpha + \beta_1 (D_1 t) + \beta_2 (D_2 t) + n\ .$$

Let $y = \ell n\ s$.

The least squares estimate of β_1 is:

$$\hat{\beta}_1 = \frac{\Sigma(y-\bar{y})(D_1 t-\overline{D_1 t})\Sigma(D_2 t-\overline{D_2 t})^2 - \Sigma(y-\bar{y})(D_2 t-\overline{D_2 t})\Sigma(D_1 t-\overline{D_1 t})(D_2 t-\overline{D_2 t})}{\Sigma(D_1 t-\overline{D_1 t})^2\Sigma(D_2 t-\overline{D_2 t})^2 - [\Sigma(D_1 t-\overline{D_1 t})(D_2 t-\overline{D_2 t})]^2}\ .$$

Let D equal the denominator in this expression. Substituting for y , and taking the expected value of $\hat{\beta}_1$, we obtain

$$E\hat{\beta}_1 = \beta_1 + \frac{A_1 - B_1}{D}\ , \text{ where}$$

$$A_1 = \Sigma[\alpha_1(D_1-\overline{D_1}) + \alpha_2(D_2-\overline{D_2})][D_1 t-\overline{D_1 t}] \cdot \Sigma(D_2 t-\overline{D_2 t})^2\ ,$$

$$B_1 = -\Sigma[\alpha_1(D_1-\overline{D_1}) + \alpha_2(D_2-\overline{D_2})][D_2 t-\overline{D_2 t}] \cdot \Sigma(D_1 t-\overline{D_1 t})(D_2 t-\overline{D_2 t})\ .$$

In this example we have an equal number of observations in each group and the same values of t in each group. Let the sum of the years for each

group be T , the sum of the years squared be T^{SR} , and the total number of observations be N . Then

$$\overline{D_1t} = \overline{D_2t} = \frac{T}{N}$$

$$\sum_1^N (D_1t-\overline{D_1t})^2 = \Sigma(D_2t-\overline{D_2t})^2 = T^{SR} - \frac{T^2}{N}$$

$$\sum_1^N (D_1t-\overline{D_1t})(D_2t-\overline{D_2t}) = -\frac{T^2}{N} \ .$$

And,

$$A_1 = \left[\frac{T}{2}(\alpha_1-\alpha_2)\right]\left[T^{SR} - \frac{T^2}{N}\right] ,$$

$$B_1 = \left[\frac{T}{2}(\alpha_1-\alpha_2)\right]\left[\frac{T^2}{N}\right]$$

$$D = \left[T^{SR} - \frac{T^2}{N}\right]^2 - \left[\frac{T^2}{N}\right]^2 = \left(T^{SR}\right)^2 - \frac{2T^{SR}T^2}{N} ,$$

$$\frac{A_1-B_1}{D} = \frac{(\alpha_1-\alpha_2) \cdot T \cdot (T^{SR}-2T^2/N)}{2T^{SR}(T^{SR}-2T^2/N)} = (\alpha_1-\alpha_2) \cdot \frac{T}{2T^{SR}} \ .$$

In this case,

$$\frac{T}{T^{SR}} = \frac{(1/2)n(n+1)}{(1/6)n(n+1)(2n+1)} = \frac{3}{2(n+1)} \ , \text{ and}$$

$$E\hat{\beta}_1-\beta_1 = (\alpha_1-\alpha_2)\,\frac{3}{4(n+1)} \ .$$

For example, if $\alpha_1-\alpha_2 = .0861$ (taken from the estimates in Appendix Table 6) and $n = 22$, the expected bias would be approximately .0027.

In a more realistic example, the bias would of course depend on the number of observations in each group and on their dispersion with respect to years employed.

Further confidence in the assumption of no appreciable variation in

starting salary by SEL and GPA was provided by a former official of a firm quite similar to the one under study. He said that his (former) firm did not pay differential starting salaries on the basis of college or GPA and he claimed that a like practice would be followed in the subject firm. A primary reason for not making these distinctions, according to him, is to avoid morale problems which would result from such a practice.

APPENDIX II

Results by Undergraduate Major and Function

Results by Undergraduate Major.

The results above are based on individuals who followed quite different curricula in college and who were performing jobs possibly requiring quite different kinds of skills. It may be reasonable to crudely classify jobs as being more or less technical in nature. These terms may be defined indirectly by assuming that persons who majored in engineering or science in college were more likely to have obtained more technical jobs and those majoring in business or liberal arts, less technical (non-technical) jobs. It might also be assumed that attributes required (or rewarded) would differ within the firm by function--engineering, finance, sales, etc. The two classifications, of course, are not unrelated, as may be seen from the distribution of persons (in the sample) by college major within each function. (See Appendix Table 7.)

The former classification has been emphasized here for two reasons. First, it was felt that differences between technical and non-technical jobs (as defined above) were likely to be more important than differences across functions within the same firm. This is not to suggest that differences by function should be neglected. For example, the nature of the work performed by business majors working in finance would be expected to be quite different from that of business majors in sales or industrial relations. Second, this classification resulted in two major groups--engineering or science and business--with a large number of observations in each.[1] Analysis by function, however, was also carried out.

[1] Liberal arts majors (plus "others") formed a third group, but with only 157 observations.

APPENDIX TABLE 7

Percent Distribution of Sample by College Major, by Function

Function	Number	College Major				
		Engineering	Science	Business	Liberal Arts	Other
Engineering	196	90.0	2.7	5.0	1.4	0.9
Manufacturing	212	46.1	7.1	34.6	10.2	2.0
Finance	174	3.8	1.6	83.3	9.7	1.6
Industrial Relations	122	5.3	6.0	47.4	32.3	9.0
Purchasing and Traffic	80	7.6	5.4	67.4	16.3	3.3
Sales	192	8.3	4.4	63.1	19.9	4.4
TOTAL	976	32.2	4.5	46.4	13.3	3.1

The results obtained from estimating Model 1 by undergraduate major are shown in Appendix Table 8. For purposes of comparison, primary emphasis is placed on the results for engineering or science and business majors. The relatively large number of observations in these two groups provide estimates which are considerably more reliable than those for liberal arts majors. This is readily seen by comparing standard errors of the estimates.

The most striking difference between the results for engineering or science and business majors is found in the relative importance of college selectivity. Although the rate of salary increase tends to rise with increases in SEL for both groups, the increase is much smaller for engineering majors.[2] If we ignore the estimated effect of being in SEL1,[3] we find that the difference between the estimate for SEL2 and SEL6 is .017 for business majors, but only .007 for engineers. The estimates for SEL2 through SEL4 are essentially the same for the engineers and scientists group.

A possible explanation for this result is provided by the following hypothesis. If one were to compare the ranges of SAT scores of students entering given colleges with college SEL ratings, one would obtain results similar to those indicated in the diagram below.[4] The vertical lines represent the range of SAT scores. At the very best schools, the mean SAT scores of persons who graduate in engineering may be close to the mean for all students. But at the poorer schools, it is hypothesized that the SAT scores of persons who eventually graduate as engineers is higher than the mean for the whole school. For example, the mean for engineers may look

[2]The appropriate F-statistic for engineers, 1.872, is significant at the .10 level but not at .05.

[3]Only a few observations fall in this category for both college major groups.

[4]For an actual comparison, but using a different selectivity measure, see Astin [1971].

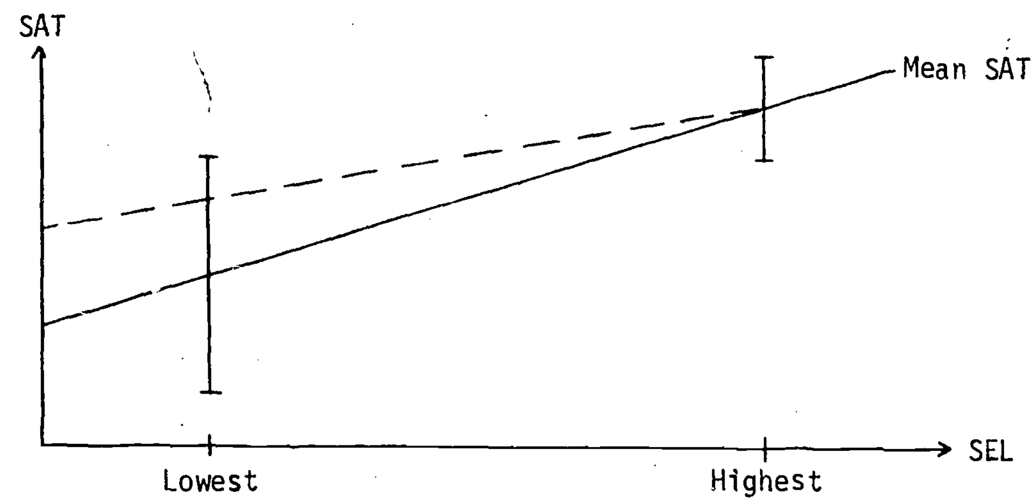
APPENDIX TABLE 8

Parameter Estimates by Undergraduate Major

	Engineering or Science	Business	Liberal Arts*
Constant	6.73623	6.06381	6.73564
BA	.03744 (.01610)	.01351 (.01465)	.28254 (.06861)
BA'	-.03744 (.01610)	-.01351 (.01465)	-.28254 (.06861)
	F = 5.407	F = .0849	
EXP	.01903 (.00486)	.01568 (.00498)	.01361 (.00776)
AV	.03953 (.00262)	.01568 (.00498)	.04164 (.00517)
SEL1	.01129 (.00629)	.01045 (.00565)	.00847 (.00548)
SEL2	-.00105 (.00193)	.00510 (.00217)	.00313 (.00280)
SEL3	-.00017 (.00216)	.00307 (.00266)	.00415 (.00411)
SEL4	-.00096 (.00164)	-.00348 (.00150)	-.00006 (.00242)
SEL5	-.00349 (.00215)	-.00310 (.00181)	-.00942 (.00282)
SEL6	-.00562	-.01204	-.00627
	F = 1.872	F = 8.423	F = 2.984
GPA1	.00556 (.00221)	.00770 (.00164)	.01234 (.00656)
GPA2	-.00015 (.00134)	.00238 (.00125)	-.00097 (.00332)
GPA3	-.00072 (.00122)	-.00274 (.00103)	-.00574 (.00284)
GPA4	-.00469	-.00734	-.00563
	F = 4.957	F = 18.100	F = 2.984
MA1 } MA2	.00705 (.00206)	.00477 (.00194)	.00049 (.00491)
MA3	-.00361 (.00219)	-.00088 (.00227)	.00654 (.00555)
MA0	-.00344	-.00389	-.00703
	F = 6.896	F = 6.449	F = 1.875
SEC	-.00220 (.00071)	-.00324 (.00066)	-.00444 (.00138)
SES	.00022 (.00049)	.00070 (.00048)	.00087 (.00089)
LEAD	.00205 (.00049)	.00220 (.00038)	.00253 (.00075)
INT	.00128 (.00044)	.00048 (.00035)	.00094 (.00069)
SUP	.00070 (.00059)	.00141 (.00051)	.00256 (.00102)
	F = 13.805	F = 18.311	F = 11.579
	N = 352 R^2 = .71291	N = 467 R^2 = .69853	N = 157 R^2 = .67318

*Includes other or not specified.

like the broken line. The primary basis for this hypothesis is that students tend to flunk out of engineering programs or transfer to other majors to a greater extent than do students starting in other areas.[5] It is assumed that the SAT scores of those remaining tend to be higher than the average of those entering. The result would be even stronger if engineers tended to have higher SAT scores than the school mean when they entered.[6] This hypothesis would suggest a weaker relationship between SEL and ability for engineers than for other students and would thus be consistent with the results obtained here.



It is also seen that the effect of GPA is weaker for engineers than for business majors.[7] The difference between the estimated effects for the highest and lowest groups is .015 for business students but only .010 for engineers and scientists. A hypothesis consistent with the explanation

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[5]For example, Astin [1965a] found that in a sample of National Merit Scholarship finalists and recipients of the letter of recommendation, the proportion of students changing career aspiration was much higher in engineering than in other fields.

[6]Casual observation suggests that this may well be the case at lower selectivity schools.

[7]This would not be true if the comparison were made using only engineers working in the engineering function. Engineers are largely employed in two functions within the firm--engineering and manufacturing.

regarding SEL is advanced here. The tendency to restrict degrees to persons with a minimum level of competence or acquired skills may be stronger in engineering schools than in business schools. An engineer would be expected to have mastered certain basic skills which would be required in a large proportion of engineering jobs. Even persons with the lowest grades would be expected to have these skills. In some states, for example, engineers are licensed by the state. This need may be less strong for business majors. Thus, for example, a C grade in engineering would indicate a relatively greater mastery of job related skills than would a C grade in business. In other words, it is hypothesized that the range of competence indicated by grades in engineering is smaller than in business. Some who are allowed to graduate in business with C grades, say, would be forced out of engineering programs.

For the group as a whole, it was found that obtaining an MA degree added substantially to an individual's rate of salary increase only if he did quite well in his graduate work. The results in Table 8 show that this effect is stronger for engineering undergraduates than for business students.

Finally, it may be seen that INT is statistically significant for engineers, but SUP is not; the reverse is true for business majors. A possible interpretation, offered for lack of a more convincing one, may be found by recalling that the INT index is likely to reflect personal traits such as imaginative thinking, initiative, or the ability to work on one's own, whereas the SUP index tends to reflect the extent to which an individual was pushed or included in the decision making process by his supervisor. The former traits may be relatively important for an engineer who might be expected to work on his own, while the latter work environment may be

relatively more important in aiding business majors whose later work is expected to be directed more toward management activities.

The pattern of the estimates for liberal arts majors is similar to that for business majors, although the standard errors are considerably higher. In this case, however, we cannot reject the null hypothesis that all the GPA effects are the same.[8] Ignoring the GPA1 group which relates to only a few liberal arts observations, we find that the difference between the estimated effects for GPA2 and GPA4 is .0096 for business majors, but only .0065 for liberal arts majors. This is consistent with the assumption that liberal arts training is less directed toward job relevant skills than either engineering or business training.[9] However, because of the comparatively small sample size, this point should not be emphasized too strongly. The MA estimates, none of which is significantly different from zero, pertain to only a very few observations and should not be taken seriously.

The values of R^2 with different sets of variables included in the regression, together with high and low estimates of the contribution of academic and non-academic variables, are shown by function in the following tabulations.

Values of R^2

Right-Hand Variables Included	Total Sample	Engineering or Science	Business	Liberal Arts**
(1) - All Variables	.690	.713	.699	.673
(2) - t (Years Employed)	.490	.543	.501	.395
(3) - t,BA,ENG,LIB,[10] EXP	.530	.583	.515	.411
(4)-(2),(3),SEL(i),GPA(j),MA(k)	.622	.653	.637	.536
(5)-(2),(3),SEC,SES,LEAD,INT,SUP	.633	.677	.612	.598

[8] F(3,138) = 1.732 is not large enough to reject the hypothesis at the .10 level of significance.

[9] Persons who reported their undergraduate major as liberal arts may have taken courses in more job related areas such as business or engineering.

[10] The last two do not apply when the regressions are by major.

The Contribution of Academic and Non-Academic Variables

	Academic Variables		Non-Academic Variables	
	Low	High	Low	High
Total Sample	.057	.092	.068	.103
Engineering or Science	.036	.070	.060	.094
Business	.087	.122	.062	.097
Liberal Arts	.075	.125	.137	.187

The percent of the variation remaining unexplained after variables (3) are included, which is explained by the academic and non-academic variables together is as follows:[11]

Total Sample	.340
Engineering or Science	.311
Business	.379
Liberal Arts	.445

Results by Function.

Parameter estimates by function[12] are shown in Appendix Table 9. College selectivity is treated as a continuous variable here. They essentially confirm those obtained from the analysis by college major. In the industrial relations function, which contains the largest proportion of liberal arts majors, none of the academic variables are significant.[13] College selectivity is not significant in the engineering function, which is comprised almost entirely of engineering and science majors; but is significant in manufacturing which is composed of approximately equal proportions of technical and non-technical personnel. If the

[11] The relatively large value for liberal arts is largely due to the small number of observations in that group. The values after adjustment for degrees of freedom are: engineering or science, .273; business, .351; and liberal arts, .273.

[12] Estimates for purchasing and traffic are not shown because of the relatively small number of observations in this function.

[13] This result should be qualified to the extent that this function contains fewer observations than any of the others.

APPENDIX TABLE 9

Parameter Estimates by Function

Variable	Engineering	Manufacturing	Finance	Sales	Industrial Relations
Constant	6.72677	6.69981	6.69763	6.71967	6.58370
BA	.06419 (.01864)*	.04126 (.02226)	.00938 (.02667)*	-.01422 (.03249)	.06877 (.04366)
BA'	-.06419 (.01864)*	-.04126 (.02226)	-.00938 (.02667)	.01422 (.03249)	-.06877 (.04366)
ENG	.01139 (.02732)	.04263 (.01462)*	.04543 (.04746)	.05825 (.02485)*	-.04383 (.03305)
LIB	-.01589 (.04528)	-.02747 (.02052)	-.00721 (.03652)	-.03396 (.02184)	.04711 (.02350)
BUS	.00450	-.01516	-.03822	-.02429	-.00328
EXP	.01827 (.00665)*	.01363 (.00565)*	.02150 (.01005)*	.01600 (.00658)*	.01905 (.01017)*
AV	.04068 (.00278)*	.03926 (.00325)*	.04258 (.00343)*	.03608 (.00407)*	.04713 (.00464)*
SEL	.00017 (.00013)	.00047 (.00012)*	.00061 (.00020)*	.00050 (.00013)*	.00029 (.00025)
GPA1	.01158 (.00249)*	.00788 (.00290)*	.00611 (.00301)*	.00810 (.00389)*	.00733 (.00451)
GPA2	.00030 (.00158)	-.00149 (.00200)	.00403 (.00209)*	-.00098 (.00250)	.00025 (.00307)
GPA3	-.00381 (.00152)*	-.00134 (.00155)	.00193 (.00196)	-.00424 (.00188)*	-.00363 (.00221)
GPA4	-.00807	-.00505	-.01207	-.00288	-.00395
MA1-2	.00756 (.00287)*	.00087 (.00346)	.00693 (.00341)*	.01130 (.00426)*	-.00066 (.00413)
MA3	-.00123 (.00254)	.00466 (.00467)	-.00133 (.00318)	-.01229 (.00555)*	.00836 (.00557)
MAO	-.00633	-.00553	-.00560	.00099	-.00770
SEC	-.00177 (.00091)*	-.00276 (.00083)*	-.00389 (.00129)*	-.00292 (.00112)*	-.00613 (.00147)*
SES	.00075 (.00060)	-.00001 (.00060)	.00001 (.00101)	-.00001 (.00078)	.00114 (.00088)
LEAD	.00199 (.00061)*	.00194 (.00053)*	.00382 (.00098)*	.00236 (.00062)*	.00234 (.00076)*
INT	.00074 (.00060)	.00208 (.00047)*	-.00045 (.00066)	.00035 (.00063)	-.00064 (.00064)
SUP	.00065 (.00078)	.00134 (.00071)	.00298 (.00109)*	.00078 (.00081)	.00354 (.00102)*
	N = 196 R^2 = .74424	N = 212 R^2 = .76293	N = 174 R^2 = .67183	N = 192 R^2 = .70149	N = 122 R^2 = .76461

*Statistically different from zero at the .05 level.

functions composed primarily of non-technical personnel--finance, sales, industrial relations--are compared, it is seen that academic variables are most important in finance. This is consistent with the observation that finance is a relatively demanding (in an academic sense) field in business.

A tabulation of R^2 values with different sets of variables in the regression may help to summarize the results by function.

Right-Hand Variables Included	Engineering	Manufacturing	Finance	Sales	Industrial Relations
(1) All Variables	.741	.763	.672	.701	.765
(2) t	.502	.505	.410	.559	.524
(3) t,BA,BA',ENG,LIB,EXP	.561	.575	.457	.590	.577
(4) (2),(3),SEL([illegible]),GPA(j),MA(k)	.702	.648	.598	.653	.660
(5) (2),(3),SEC,[illegible]ES,LEAD,INT,S[illegible]	.675	.713	.561	.651	.733

From these can be calculated high and low estimates of the contribution of academic and non-academic variables, as was done in a previous tabulation. The results are as follows:

Function	Academic Variables		Non-Academic Variables	
	Low	High	Low	High
Engineering	.069	.141	.042	.114
Manufacturing	.050	.073	.115	.138
Finance	.111	.141	.074	.104
Sales	.050	.063	.048	.061
Industrial Relations	.032	.083	.105	.156

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